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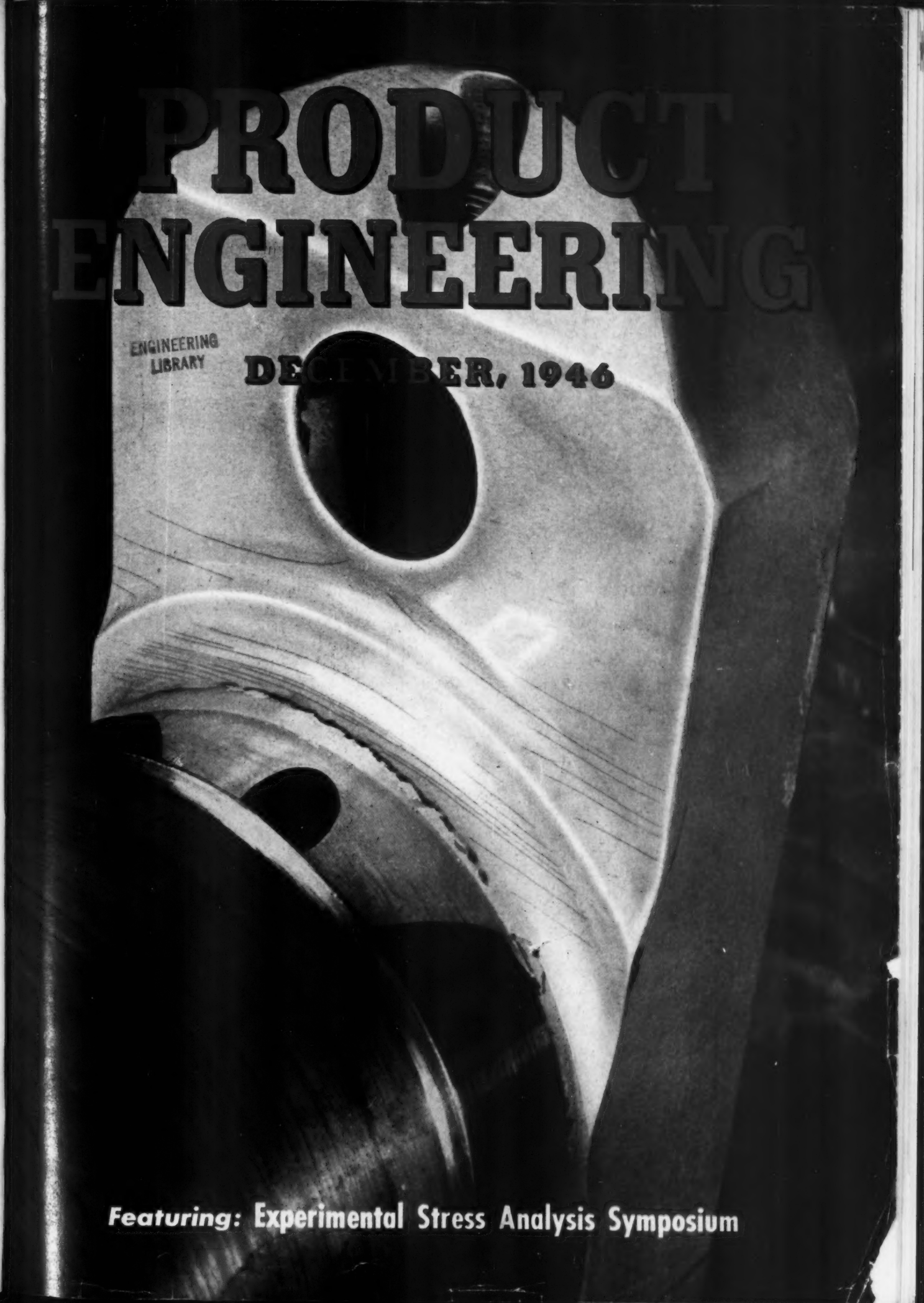

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35,000 Lathe Beds prove it!

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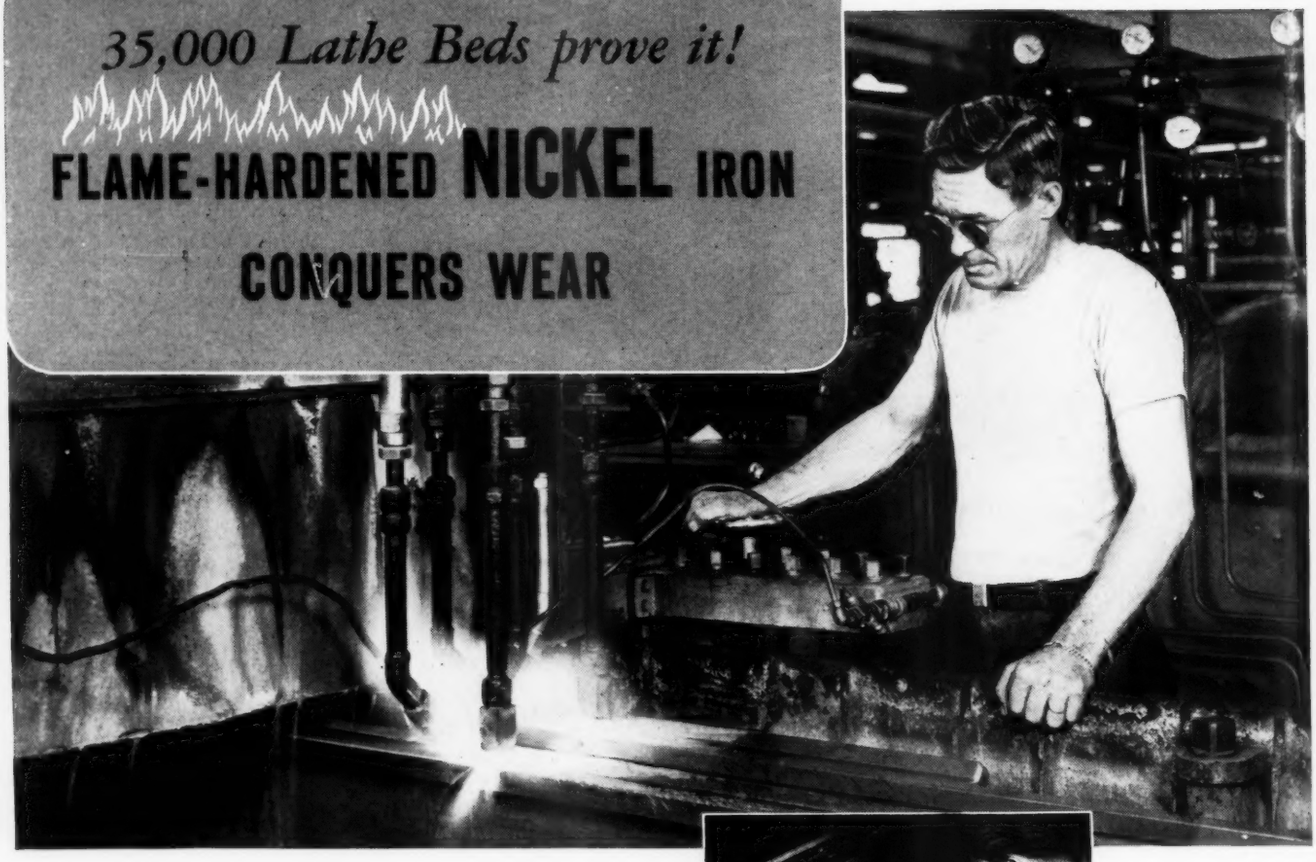


During the past 5 years The Monarch Machine Tool Company has built more than 35,000 lathes.

So, they know a lot about lathes . . . and lathe *beds,* too.

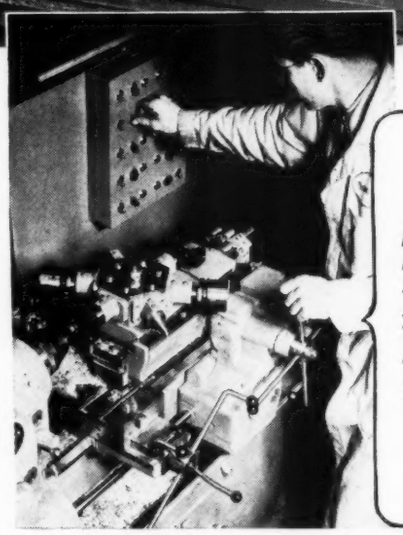
They know how to build beds that resist abrasion, scoring, wear . . . and maintain high accuracy to keep users' production costs low.

That's why Monarch specifies Nickel alloyed iron for all beds.

Experience shows good reason for this. For example, when their Nickel iron lathe beds, 8½ feet long, are flame-hardened to a depth of ⅛″ to ¼″, the warpage is only about 0.01″. During finishing, this is ground off and final tolerance is only 0.0005″.

The Nickel in the cast iron lowers the critical transformation range . . . thus, gives greater depth of hardness than in plain iron and minimizes distortion. Moreover, there is gradual blending of the flame-hardened layer into the softer pearlitic interior, whereas in unalloyed iron the transition zone is apt to be completely graphitized and hence extremely weak.

Consult us on the use of Nickel to meet your casting requirements. Send us details of your problems today.



In this SPEED-MATIC *hand screw machine, Monarch uses gears, shafts and pinions of Type 8749 Nickel alloy steel, along with flame-hardened Nickel cast iron beds.*

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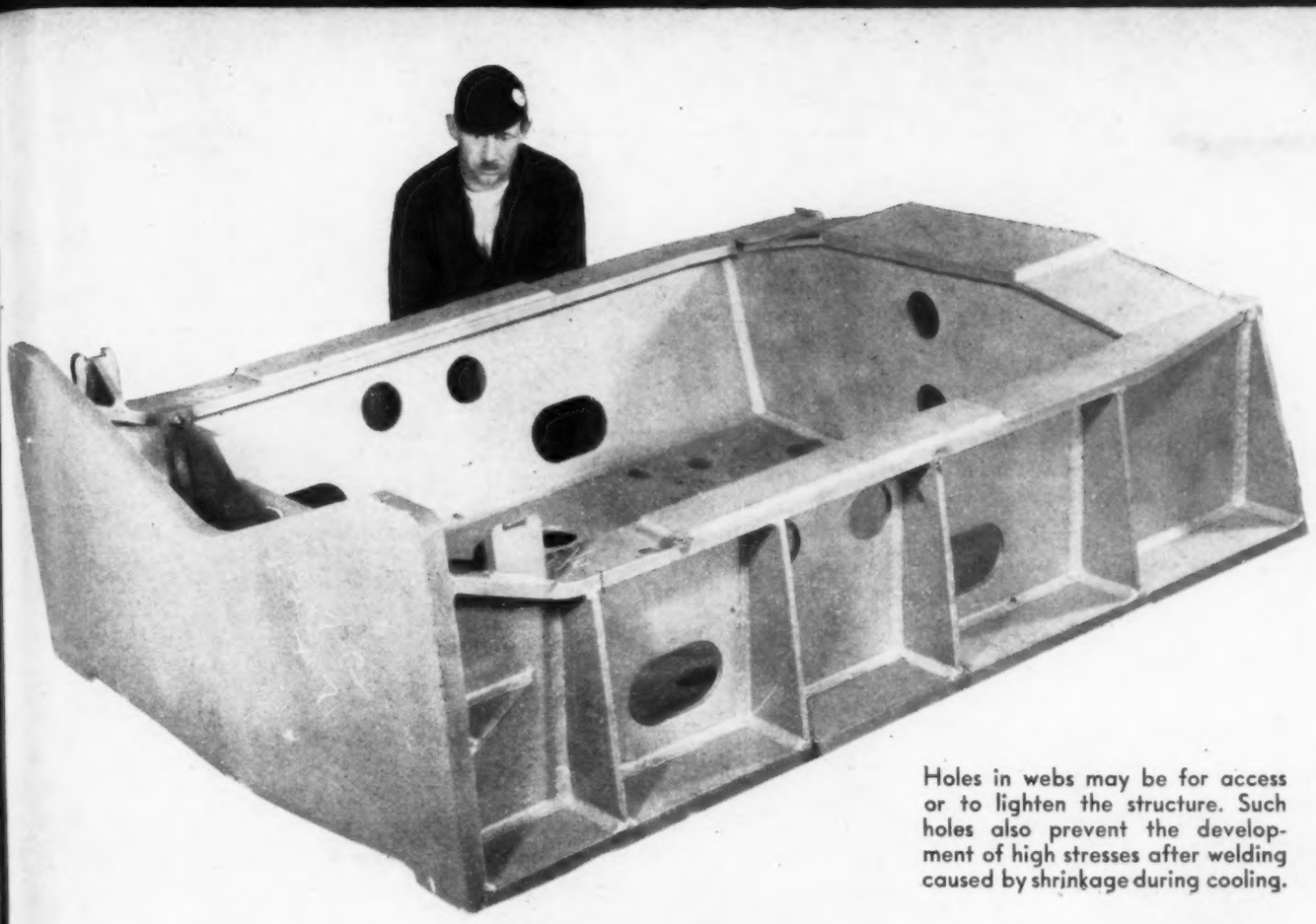


Holes in webs may be for access or to lighten the structure. Such holes also prevent the development of high stresses after welding caused by shrinkage during cooling.

What Changes to Improve Welding Codes and Specifications?

Criticisms of welding specifications and suggestions to improve them have been numerous in recent months. Some of the criticisms may merit consideration; some of the suggestions may be worth incorporating into future specifications. Accordingly, the following criticisms and suggestions are presented with the hope that they may stimulate interest and action toward the preparation of better specifications.

WHEN IT BECAME obvious that high quality welded products could be designed and produced economically and efficiently, the next step was the development of codes and specifications covering the electrode material, the designs of the welds, the certification of welding procedure and the qualification of welders. The establishment of any code or specification always reflects the state of the art at the time the code is written. With the passing of time, the specifications as originally written become out of date. To meet this condition, it is customary to issue supplementary specifications at frequent intervals. However, this does not entirely solve the problem because of the lag between a new discovery or development and its general acceptance.

Another weakness in standards and specifications is inability to write them to cover all conditions and applications. To take care of uncertain and unforeseeable conditions, welding codes frequently specify that certain decisions be left to the judgment of the inspector. This gives the inspector the opportunity to be autocratic, but fortunately, according to the experiences of welding production supervisors and design engineers, official inspectors are generally well-trained, high calibre men, and there is little or no criticism with reference to their decisions and operations.

Two nationally recognized codes dealing with welding are the A.S.M.E. Boiler Code and the American Welding Society Specifications. Most of the other welding codes, including those of the Maritime

Commission and Bureau of Marine Inspection and Survey, The U. S. Navy, U. S. Coast Guard, the Navy Bureau of Ordnance, the Army Ordnance Department, the U. S. Army Engineers, the U. S. Army Transportation Department, all draw heavily on the specifications of the A.S.M.E. Boiler Code and the American Welding Society in the compiling of their own specifications. Unfortunately, in order to give a stamp of individuality to the specifications and to meet what are considered special requirements, all the Army and Navy Codes differ in some details from the national specifications of the American Welding Society and the A.S.M.E. Sometimes this creates perplexing situations. For example, the qualification tests and procedure specifications are the same as those set forth in the A.S.M.E., for the U. S. Navy, Coast Guard and the Maritime Commission. However, different qualification tests and procedures are demanded by the Army Engineers, the Army Transportation Department, the Air Corps and the Ordnance Department. Unfortunately, these last named government bureaus have firmly resisted the adoption of the A.S.M.E. qualification tests and procedure specifications.

Perhaps one of the biggest causes for inconsistencies in welding specifications is created by the failure of the specifications to relate the requirements to the stress conditions encountered by the weld. For example, the inspection codes prohibit overlap of the weld metal such as might occur in the butt weld shown in Fig. 1 for the reason that such an overlap creates a point of stress concentration. On the contrary, such stress concentration cannot develop unless there is an appreciable stress component in a direction perpendicular to the direction of the weld. If the direction of the principal stress is parallel to the weld, there will be no stress across the weld and hence no stress concentration created at the overlap of the weld metal.

Ironically, the codes permit an overlap strip to be placed under the weld in order to make possible more economical welding operation. When such an overlap strip is used, the stress conditions are analogous to those that pertain when an overlap of the weld metal is produced. In fact, such a design is often referred to as a designed overlap. The codes permit such a design of weld for both steady and cyclic loads in the direction parallel to the weld, whereas an overlap of weld metal is not acceptable under the same conditions. Apparently the overlap of the weld metal is not acceptable solely because of its appearance.

Numerous other welded constructions wherein the weld metal itself carries little or no stress can be cited. Two examples are the channel and the rib stiffener,

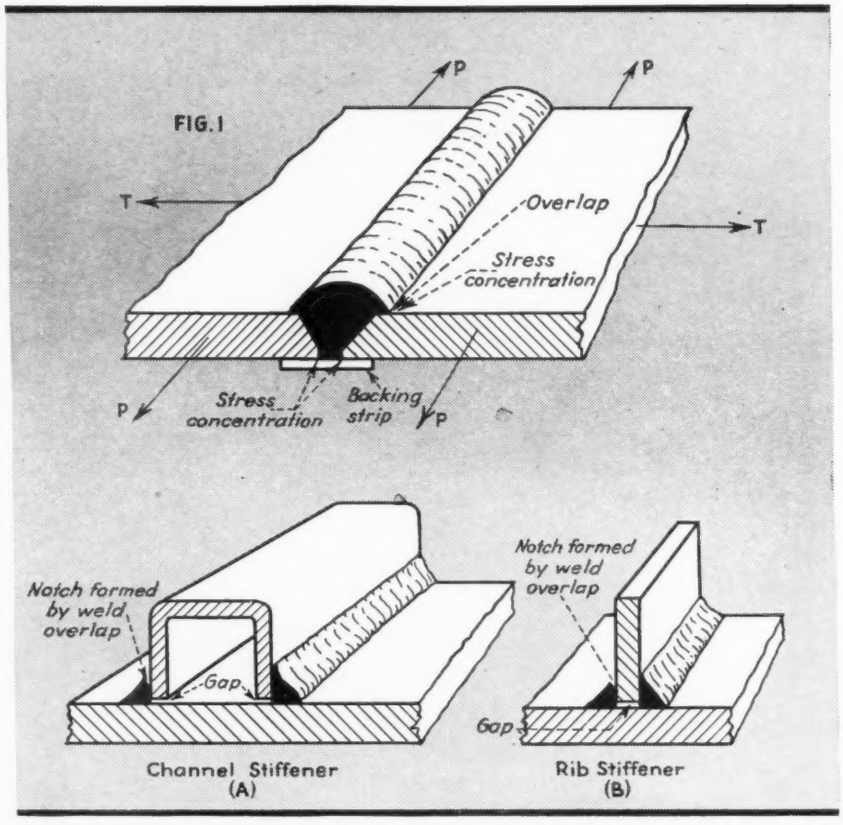


Fig. 1—Designed overlay butt weld with the weld metal overlapping. Codes prohibit a back strip or overlap when the stresses are in the direction T. When stresses are in direction P, the backing strip is permitted but not the weld metal overlap. For given stress conditions, the gaps indicated at (A) and (B) are points of stress concentration just as are the notches formed by the weld metal overlap. Latter are prohibited by codes because of high stress concentration.

shown in Fig. 1. Both constructions of necessity have a gap, as shown in the illustrations. The gaps are open seams; under certain stress conditions they become points of stress concentration. However, the stress conditions that would create stress concentration do not exist in the conventional designs wherein such sections are used as web stiffeners. For the same reason, overlap of the weld metal is of no moment if the web and the stiffener and the weld are engineering-wise sound. In other words, if internal notches are permissible, external notches created by overlap of the weld metal should also be permissible.

In some instances, the weld specifications are engineering-wise unsound. For example, when welding was in its infancy, the kowledge concerning stress concentration created by discontinuities also was relatively in its infancy. On the other hand, because of the variable qualities of the welds of those days, it was considered desirable to thicken the metal at the welded joint by the addition of surplus weld metal. The American Welding Society shows a heavy bead on both sides of a butt joint, such as shown in Fig. 4. For repeated or cycling tension loads, such a joint is not so strong as one in which the weld metal is flush with the surfaces of the joined plates. Similarly, the American Welding Society at one time specified reinforcements for fusion welded butt joints, such as shown in Fig. 5. Such a joint has relatively low strength in fatigue because the abrupt changes in cross-section create high stress concentrations.

The use of straps to reinforce a butt welded joint clearly indicated, at least in the early days it was not recognized, that the stress conditions in a welded joint are entirely different from those in a riveted joint. Yet in spite of the fact that this point has been repeatedly stressed in the pages of the technical press, at technical meetings and in much of the literature devoted to welded design, there still are to be found welded designs that are obviously based on mere imitations of riveted constructions.

The welded lap joint shown in Fig. 6 is perhaps the most common design error in welded construction. Experienced welding engineers report that the lap welded joint crops up repeatedly in the designs they receive from their clients. Any designer who takes the time and

trouble to make a complete analysis of the stress conditions in a lap welded joint will readily see the weaknesses in such construction. Such a joint in tension is under eccentric loading as indicated in Fig. 6. This creates a complexity of stresses in the weld metal, resulting in a combination of shear and tensile stresses. Under fatigue loading or repeated tension loads, the conditions are aggravated by the space between the faying surface of the plates joined. These conditions can be largely eliminated by the use of butt welds instead of the lap welds, which imitate riveting. Proper precautions must be taken in the design of butt welded joints as illustrated in Fig. 7. The single-V weld is bound to leave a notch at the root of the weld because of the incomplete penetration of the weld metal, which is difficult or impossible to flow into it.

For repeated stresses of appreciable magnitude, it is essential that internal notches be eliminated, preferably by the use of a double-V butt weld that secures complete penetration. Such a design is not always practical because of the impossibility of being able to weld from both sides. However, the designer must develop the design so that the position of the weld will permit welding from both sides, or the joint must be so designed that it will not be subjected to high unit stresses.

A similar condition may be encountered in the design of welded joints between plates and castings. Fig. 8 is an example. In order to serve both to position the plate and as a backing strip, a lip was placed along the edge of the high alloy steel casting as indicated. The weld joint was a single-V and therefore, there was bound to be a notch where the lip of the casting laid against the steel plate. Under high loading, shock conditions and repeated stresses, this notch became the beginning of a fatigue crack. The abrupt change in cross-section aggravated the conditions. A far superior design is that shown to the right of Fig. 8 wherein the steel plate is butted against the alloy steel casting and welded to it from both sides.

Another common error in the design of welded construction is the failure of the designer to take into consideration the shrinkage stresses developed in welding operations. Shrinkage stresses can only be eliminated by allowing the metal to shrink without restraint. Shrinkage stresses are bound to develop when a solid plate or web is welded along all four edges. The magnitude of the stresses will depend upon the dimensions, as well as the care exercised in welding. Such a condition is encountered in a web plate welded to a top and bottom chord, with vertical web stiffeners welded on at intervals. If the distance between the chords or between the web stiffeners is relatively small, the shrinkage stresses will Such a condition is encountered in a web These tension stresses can be largely avoided by the simple expedient of putting a hole in the center of the web, thus permitting the metal to yield without much

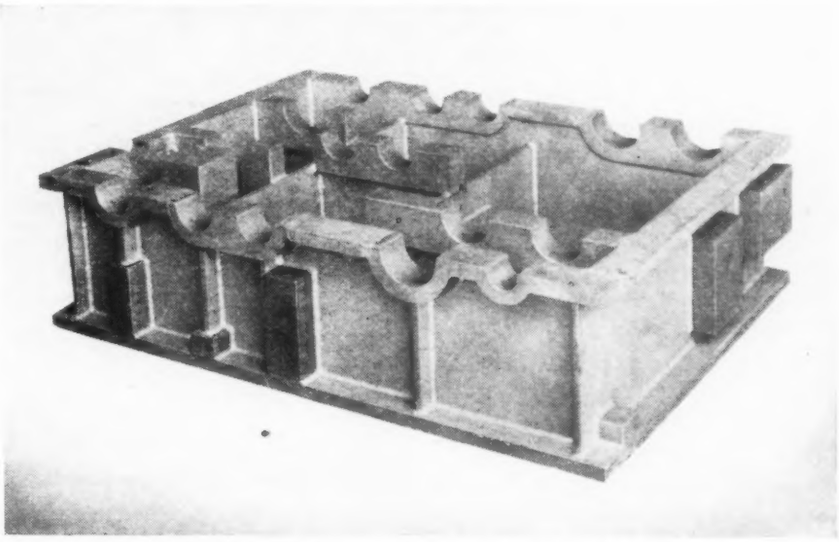


Fig. 3—Lower half of a 7,500 lb. main drive box fabricated from plates and flame-cut parts, grit blasted and stress relieved after welding.

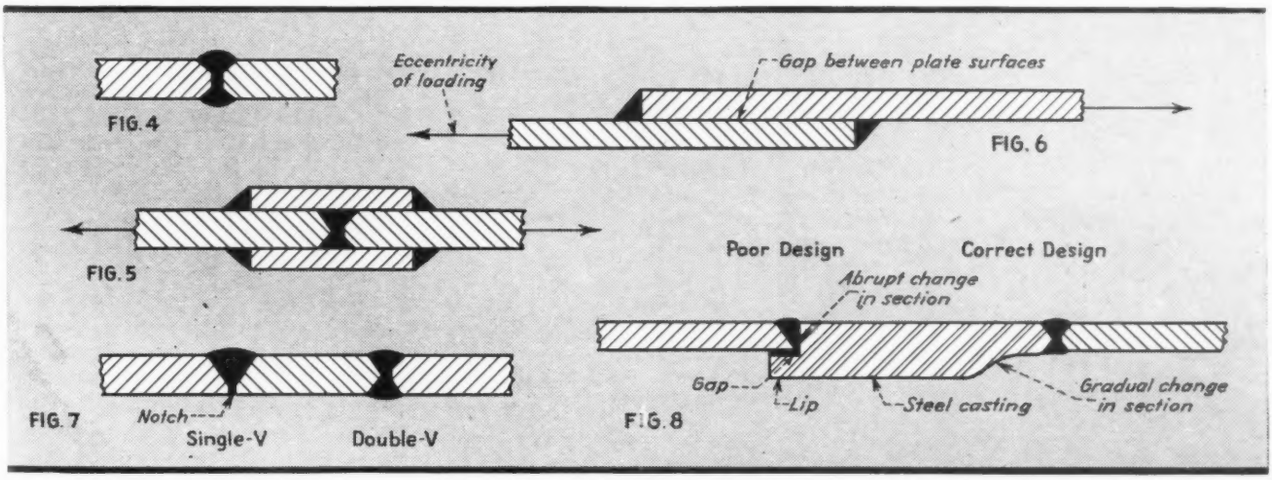


Fig. 4—Heavy beads ostensibly for the purpose of reinforcing a butt weld in reality form abrupt discontinuities of cross-section and thereby create points of stress concentration. Fig. 5—In this design the addition of the butt straps is not only a useless expense but actually results in a poor joint because of the abrupt changes in cross-section. Fig. 6—The lap welded joint is a throwback to riveted design. Such a welded joint is inefficient and inherently unsound. Fig. 7—Single-V butt welds are bound to have a notch near the bottom of the joint. For repeated stresses a double-V weld free of notches should be used. Fig. 8—In a highly stressed structure the weld design shown to the left is a poor one. To the right is shown the correct design where the section change is gradual.

restraint. Preheating, if it can be done, also reduces shrinkage stresses.

Designers of welded constructions may fail to take into consideration the fact that many of the high alloy steels must be preheated in the welding operation. If the shape and size of the design is such that preheating is impractical, the designer must change to a steel that will not require preheating. This situation is not infrequently encountered in the design of pressure vessels wherein the design calls for internal pieces of high alloy steel to be welded in place. The preheating temperatures required are such that it will be virtually impossible for a welder to go into the tank to do the welding.

One of the greatest deficiencies in the present Boiler Code of the A.S.M.E. is that it does not properly cover provisions for stainless steel constructions, although some specifications do cover the welding of stainless steel. Criticisms of the latter have been that the Code requires qualification of welder and procedure like that for the other alloy steels.

Unduly restrictive provisions are also found in the provisions of the American Welding Society, particularly with reference to railway and highway bridges. These provisions require tests of the electrodes to be used or a sworn statement that the electrodes conform to the properties of previously made and accepted electrodes. The Code also requires procedures and operators tests. Here again, there is conflict with specifications by The Hartford Steam Boiler Inspection and Insurance Company, which do not recognize welders who have passed the tests required by the Navy.

The A.S.M.E. Boiler Code is issued every three years, the last edition being dated 1943. A revised and re-edited Code is about to be issued. This forthcoming edition of the A.S.M.E. Boiler Code has been vastly improved by re-editing, credit for which is to be given to Mr. Leonard Cogan of the Philadelphia office of the Graver Tank Company.

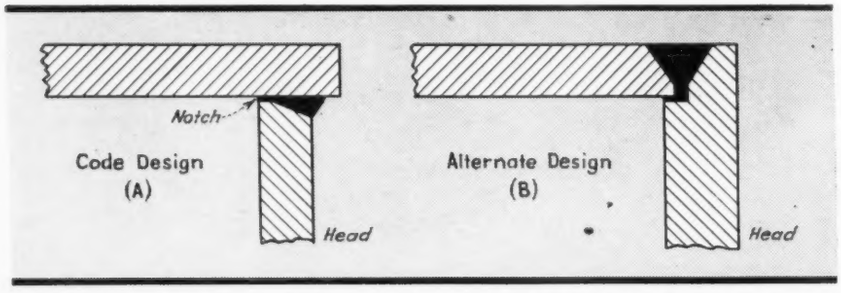


Fig. 9—In both of these designs of flat head weld to shell of pressure vessel, there is a notch. Both designs can be made equally strong, but the code does not permit the alternate design.

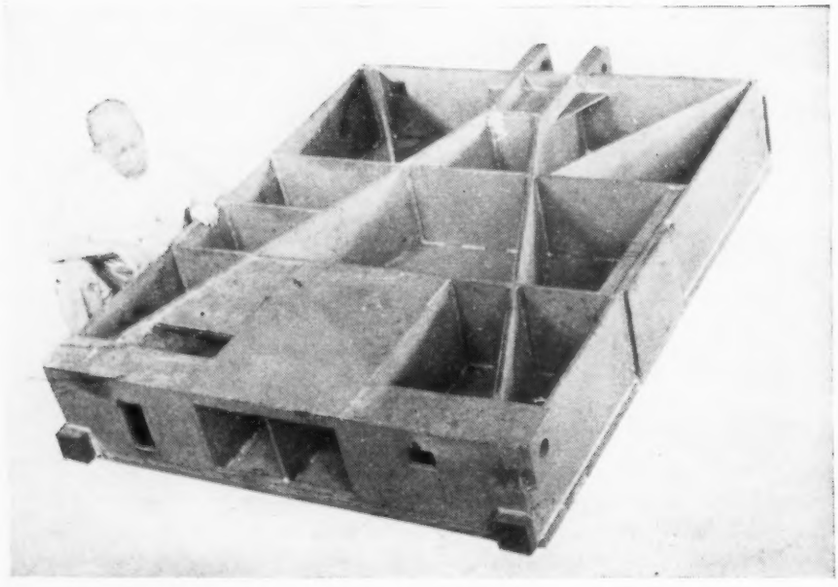


Fig. 10—Welded machine base weighing almost 4,000 lb., with heavy stiffening webs to give desired rigidity. Because the stresses at the junction of the webs and base plate are low, skip welding is used and it is of no consequence if the welds are overlapped or undercut.

The improvement is almost entirely a matter of the rearrangement of the Code in order to make it easier to use. The previous edition, insofar as the designer is concerned, had the information largely scattered. For example, the basic requirements for the design of shells for internal pressure vessels appeared in the front part of the book and the data on external pressure vessels were found in the back of the book. Tolerances for out-of-roundness of the shell for internal and external pressure vessels were found in the back of the book. The 1943 Code also had little or no data on the design of reversed dished heads for either pressure on the concave or the convex side. The specifications merely gave a note to the effect that such constructions must be tested to destruction, the Code permitting the use of the vessel at a specified fraction of the bursting pressure.

The 1943 A.S.M.E. Boiler Code also placed unnecessarily stringent limits on the positioning of welds. The Code provisions and specifications for welding a flat head into the shell shows the most expensive way of doing it, the quality of the design not being superior to other methods as used in practice. An alternate design commonly used and of proved quality is shown in Fig. 9. It will be observed that the construction specified by the Code requires considerably more weld metal. Possibly, the alternate design, not accepted by the Code for flat heads was condemned because the weld does not seal any laminations that might exist in the flat head whereas the Code design seals such laminations. However, it is significant that although the alternate design has been used extensively, there have been no failures traceable to this cause. It is also of interest that both the Code design and the alternate design have a notch in the weld as indicated in the figure.

Another code requirement that conflicts with acceptable and more economical construction, is in the material specifications. For example, there are many designs of cylindrical pressure vessels that must rotate on trunnions. It can readily be shown that because the trunnions must be designed on the basis of the required bearing area, the trunnions will be several times larger than required for strength. Therefore, the stresses developed in the trunnions or in their welded attachments to the shell will be relatively low. However, in order to assure against failure, the A.S.M.E. Code requires these trunnions to be made of forgings, and does not permit the use of hot-rolled bars. In fact, the 1943 Boiler Code does not provide any hot-rolled bar specifications and therefore the designers are compelled to specify the forged bars. There is no reason why hot-rolled bars are not adequate for the purpose.

Nonferrous Alloy Materials For Mechanical Springs

F. P. ZIMMERLI
Barnes-Gibson-Raymond Division, Associated Spring Corporation

Physical and chemical properties of the commonly used nonferrous alloy spring materials are listed. The proper application and limitations of the materials under conditions requiring electrical conductivity, corrosion resistance or resistance to loss of load at elevated temperatures are discussed.

PHOSPHOR BRONZE is perhaps the most useful of all the common copper alloys used in the production of nonferrous mechanical springs. It is available in two grades designated as Grade A and Grade C. The properties of these two grades are outlined in A.S.T.M. Specifications B103-44 for flats and B159-44T for wire. Grade A contains about 4-1/2 percent tin and Grade C about 8 percent. The best physical properties are obtained with the greater tin content.

Phosphor bronze owes all its strength to the cold-working that goes into producing it. Therefore, highly stressed springs should be made from an extra spring temper material, if the part can be fabricated from it. Often parts, both wire and flat, have such sharp bends that a lower temper or hardness must be employed. When both alloys are equally available, Grade A will usually be used because, unless extra strength is essential, this grade will cost less to procure per pound on the basis of usable tensile strength. Since the phosphor bronze alloys do not respond to any heat-treatment except annealing, many springs are simply formed and shipped. This practice of spring making has resulted in poor quality springs for, while the alloy does not respond to heat, the stresses trapped in the parts will. A stress relief of 325 to 350 deg. F. after fabricating, will stop much so-called drift or spring settling and such a treatment should be given important springs.

Phosphor bronze does not stand elevated temperatures well and should not be used over 225 deg. F. at stresses greater than 20,000 lb. per sq. in. even after the 325 to 350 deg. F. treatment suggested. For many electrical uses, static spring loading, and places where the loading is infrequent, phosphor bronze compression springs are stressed 50,000 to 80,000 lb. per sq. in.

depending upon wire size. This corresponds to a stress of 100,000 to 150,000 lb. per sq. in. in bending.

Brass Springs

Brass is gradually being displaced as a spring material. The usual analysis of spring brass is 64 to 72 copper with the balance zinc. The material is produced by cold-drawing and cold-rolling and is used to resist corrosion in applications where a cheap nonferrous material is suitable. The elastic limit in bending is around 40,000 to 60,000 lb. per sq. in. In torsion, working stresses of 25,000 to a maximum of 40,000 lb. per sq. in. static stress are permissible. Brass is usually not used at temperatures over 215 deg. F. because it has poor resistance to setting under load at elevated temperatures.

Beryllium Copper Springs

Beryllium copper consists of about 2 percent beryllium and 0.50 percent total iron, nickel and cobalt in copper. A.S.T.M. Specification B120-41T gives the permissible chemical analysis and lists typical properties. Its most valuable quality is that it can be formed cold in the soft state and hardened by a simple heating between 525 to 725 deg. F. This material is softened by quenching in water from 1450 deg. F. with the result that the copper beryllium compounds, dissolved by the copper at the high temperature, are kept in solution. At room temperature, precipitation of these insoluble materials cannot occur, so the metal can be shipped dead soft as it is quenched or with various amounts of cold work done after quenching as in the other copper alloys. Reheating between 525 to 725 deg. F., which causes precipitation from solid solution, hardens the metal to Rockwell C38 to 42. Cold-working after quenching increases the speed of copper-beryllium particle precipitation so that it is best to make parts from as hard a sheet or wire as can be formed. Lower temperatures and less time will be required to harden, and distortion caused by high temperature will be minimized.

Beryllium copper is the best electrical conductor of any alloy used in springs at anywhere near its hardness. With the advent of an electronic age, the use of this alloy should increase markedly. It is stronger than the other copper base spring materials and has a better fatigue resistance. It does not compare with steel in fatigue life, except under conditions where steel is corroded and copper beryllium is not; nor does it resist the combined effects of heat and stresses as steel does.

Like all copper base alloys, beryllium copper will not resist corrosion by the sulphides, which are present in some waters. It resists the common acids, salts, sea water and fresh water, just about as well as pure copper. Like copper, it will exhibit galvanic corrosion when in contact with brass, zinc, aluminum or iron. This tendency, being present to no greater extent than in copper itself, does not greatly hamper the use of the material. Beryllium copper alloy deteriorates badly when exposed to halides at slightly elevated temperatures; hence, it cannot be used where exhaust gas from tetraethyl lead is present.

Some springs are made of beryllium copper that has been cold-worked to reasonable spring properties. This is miscalled pretempered material and will not give the results that the proper heat-treatment develops. A poorly quenched structure that gives, on precipitation heat-treatment, an uneven distribution of large particles of the copper-beryllium compound will detract from its spring properties. The stress range in torsion of the alloy for 10,000,000 cycles is in the neighborhood of 25,000 lb. per sq. in. if the initial stress is 20,000 lb. per sq. in. When used in springs where fatigue is not a critical condition, torsional stresses of 60,000 to 80,000 lb. per sq. in. are used. Bending stresses can be proportionately greater when this type of spring is designed.

Silicon Bronze Springs

The producers of copper base spring materials put out, under various trade names, a spring bronze, which contains about 3 percent silicon. Some types contain up to 1 percent of manganese, while others have 1/2 percent of tin present. This type of copper alloy called spring bronze, is less expensive than phosphor bronze and can be used in many applications just as well as phosphor bronze. Its corrosion resistance is about that of copper. The physical properties, as listed by the various producers, are but slightly lower than Grade A phosphor bronze. Specifications for wire and sheet are in the A.S.T.M. Standards. The modulus is 15,000,000 lb. per sq. in. in bending and 5,000,000 lb. per sq. in. in torsion. It should be stress-relieved after forming in the same manner as phosphor bronze.

Nickel Silver Springs

The nickel silver alloys, or German silvers as they are sometimes known, are alloys of copper, zinc and nickel, with the major element being copper. The nickel content ranges from 10 to 30 percent in various mixtures. One of the most common spring alloys contains 18 percent Ni, 25 percent Zn and 56 percent Cu. The tensile values are between 135,000 and 150,000 lb. per sq. in. with a hardness of Rockwell B95-100. This material is of better quality than brass and is used where its silver color is desired. It is quite corrosion resistant, but there are many alloys more resistant so that it does not have extensive use in this field.

Nickel Alloy Springs

The four nickel alloys most used in springs are Monel, K-Monel, Inconel and Z-Nickel. Of these, K-Monel and Z-Nickel are heat-treatable, while Monel and Inconel can be strengthened by mechanical working only. All of these alloys are better resistors than the previously discussed copper alloy; Inconel being the best. They should not be used if high electrical conductivity is desired.

Monel metal has a nominal composition as follows:

Nickel	63.0–70.0
Copper	Balance
Iron	2.5 max.
Manganese	2.0 max.
Silicon	0.5 max.
Carbon	0.3 max.
Sulphur	0.02 max.

The strength of the material ranges, depending on the size, from 100,000 to 160,000 lb. per sq. in. It has excellent corrosion resisting properties and hence is often employed in mechanisms handling food products. It is slightly magnetic. Its resistance to temperature and stresses are quite good, if the temperature is 400 deg. F. or less and the stress is not over 45,000 lb. per sq. in. in torsion (corrected for curvature) or 80,000 lb. per sq. in. in bending. The hardness values run from Rockwell C 23 to C 28. Monel springs are heated to 575 to 650 deg. F. after forming to stress relieve them.

K-Monel is an age hardenable alloy and is an improvement for some uses over Monel in that it is non-magnetic. It responds to cold-work as does Monel. The nominal composition is:

Nickel	63.0–70.0
Copper	Balance
Iron	2.0 max.
Manganese	1.5 max.
Silicon	1.0 max.
Carbon	0.25 max.
Sulphur	.....
Aluminum	2.0–4.0

The alloy can be cold-worked and then heat-treated at 1,000 deg. F. to tensile strengths of 160,000 to 180,000 lb. per sq. in. The alloy must be held at this temperature for at least 6 hours and cooled slowly to 900 deg. F. at not more than 15 deg. per hour. It can be used in the cold-drawn condition where it has properties similar to Monel metal. If used as cold-drawn, the springs should be stress relieved at 575 to 650 deg. F. K-Monel will stand 500 deg. F. when subjected to moderate stresses.

Inconel is an alloy that responds to cold-

work and is not heat-treatable. The nominal analysis is:

Nickel	75.00 min.
Copper	0.5 max.
Iron	9.00 max.
Manganese	1.0 max.
Silicon	0.5 max.
Carbon	0.15 max.
Sulphur	0.02 max.
Chromium	13.00 to 16.00

The tensile properties vary with material thicknesses from 160,000 to 180,000 lb. per sq. in. This material is more resistant to heat and corrosion than any other nickel spring alloy. At reasonable stresses, it will withstand temperatures of 650 deg. F. Recent tests have indicated the possibility of making this material go to 900 deg. F. under special conditions with some set allowed. All Inconel springs should receive a stress relief temperature of 900 deg. F. for at least one hour. They will then have a hardness of Rockwell C 30-40, as the size goes from 3/8 in. wire downward or 1/8 in. sheet and thinner.

Z-Nickel occupies a place between K-Monel and Inconel. It can be cold-worked and heat-treated. Published analyses of this alloy give only the following composition:

Nickel	98.61
Copper	0.03
Silicon	0.14
Sulphur	0.005
Iron	0.14
Manganese	0.05

The usual requirements call for 98 percent minimum nickel and that the alloy shall be able to age harden. After a solution treatment consisting of quenching from 1,950 deg. F. and age hardening at 900 deg. F. for 4 to 8 hours, depending upon the hardness and size of the parts, its tensile strength in mechanical spring sizes ranges from 240,000 to 180,000 lb. per sq. in. As drawn to spring temper, the tensile strength will range from 150,000 to 200,000 lb. per sq. in., and it is quite usable for many springs with no heat-treatment employed. Z-Nickel will stand higher stresses than Inconel at temperatures up to 500 deg. F. At temperatures of 600 deg. F., or more, it will not be found desirable to use this material. Z-Nickel is about as corrosion resistant as pure nickel.

When empoyed in compression springs, the curves shown in Figs. 1 and 2, taken from the work of Betty, MacQueen and Rolle in the *Transactions of the American Society of Mechanical Engineers*, 1942, give a summary of the properties of these alloys. All stresses reported are corrected for curvature.

Another important alloy of nickel is Elinvar. This material is used in scale springs, hair springs, watches, bourdon tubes, tuning forks and similar applications, because of its constant modulus from —150 to +300 deg. F. There are several "Elinvars" available, but most of their compositions will fall within the following analysis range.

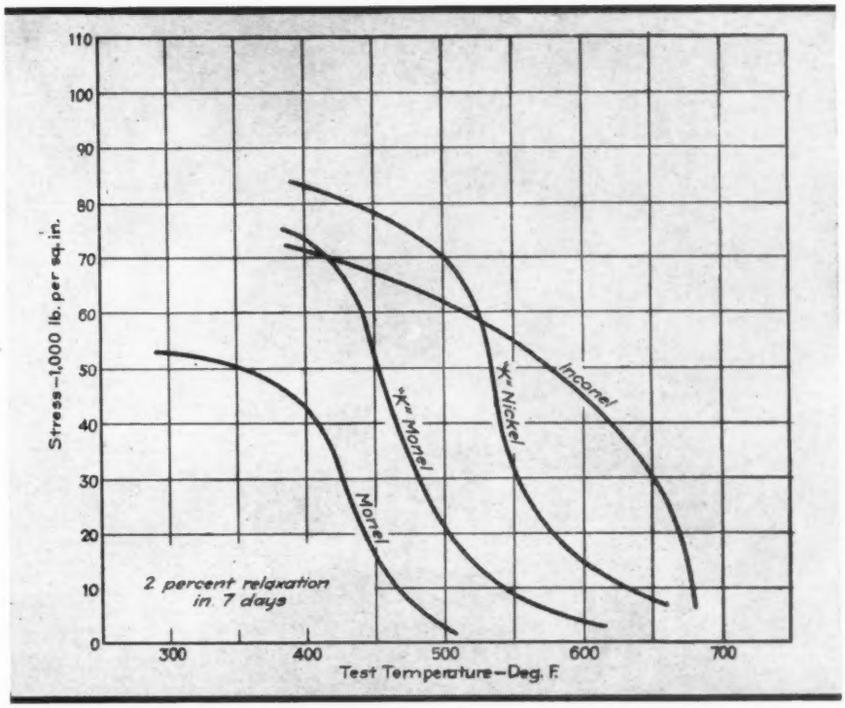


Fig. 1—Stress required to produce 2 percent relaxation in seven days.

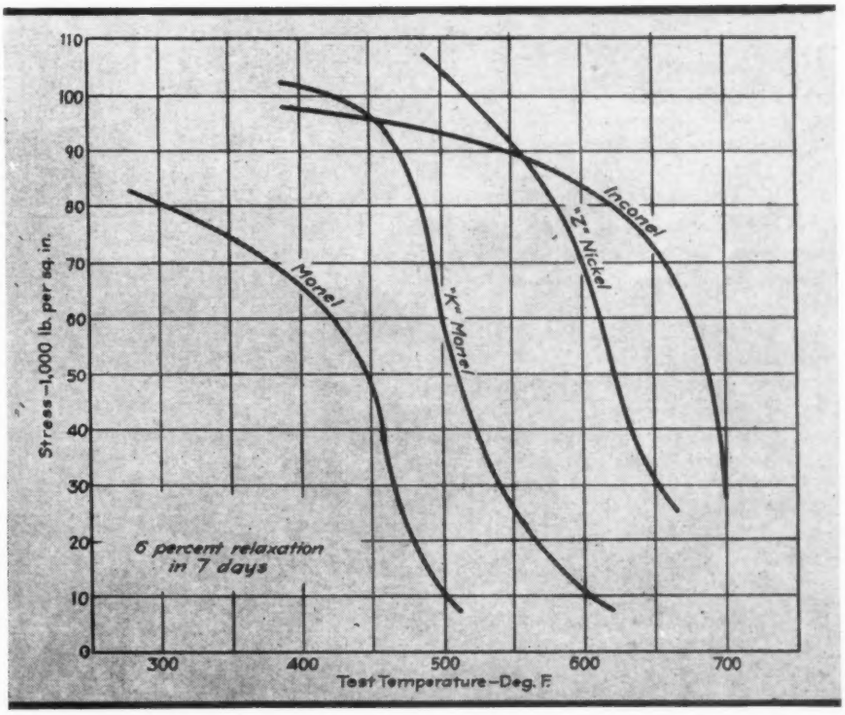


Fig. 2—Stress required to produce 6 percent relaxation in seven days.

Nickel	33–35
Iron	61–53
Chromium	21–5
Tungsten	1–3
Manganese	0.5–2
Silicon	0.5–2
Carbon	0.5–2

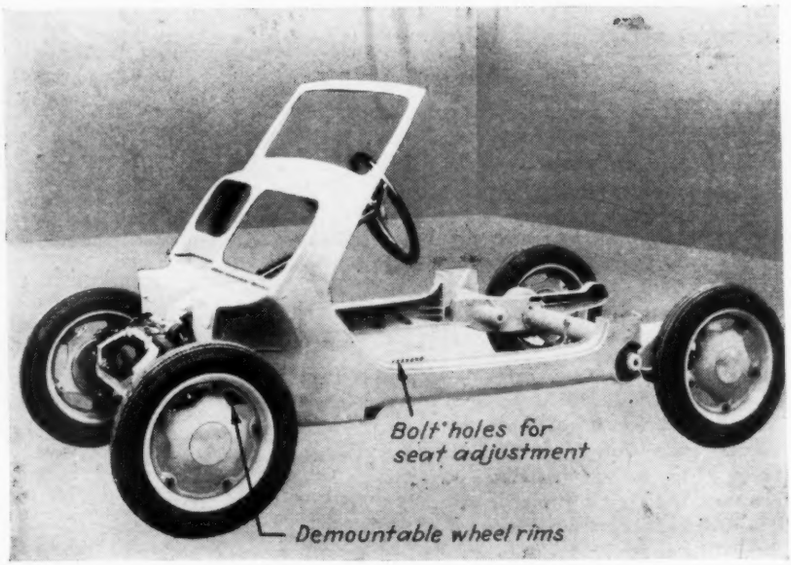
This material is austenitic and can only be hardened by cold-work. The elastic limit is about 45,000 lb. per sq. in. and in use it is limited to stresses considerably less than this. Elinvar possesses great resistance to oxidation and corrosion, is immune to magnetic effects and has low thermal expansion. Thus, it becomes an ideal precision spring material.

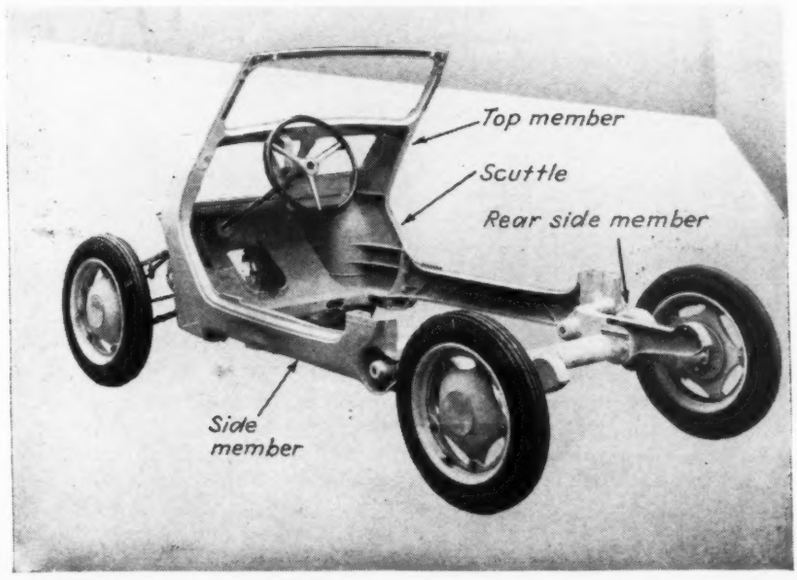
PRODUCT DESIGNS

Automobile Designed for Light Alloy Construction

EXTENSIVE use of aluminum alloys for both frame and engine components is exhibited in the Kendall 15-hp. automobile. The engine is an air cooled, two-cylinder four-stroke flat twin type. Other design features are independent front and rear wheel suspension, front wheel drive, engine, transmission and differential designed for unit installation, alternate cooling system, and a steering pivot housing that carries the car load. The body is an assembly of four units of pressed steel sheet. The four-seated touring car model has fixed door and window frames that support a removable fabric roof. J. A. Gregoire, French automotive designer and inventor of the Tracta Joint, designed the car.

Based on the premise that the successful use of aluminum alloys depends on designing for aluminum rather than merely substituting it for ferrous metal, Gregoire claims favorable comparison of the Kendall with the Ford V-8 in all-around performance. The Kendall has 35 percent less displacement than the V-8 and weighs 1,050 lb. The power-weight ratio gives a performance of 60 m.p.g. at 37 m.p.h. Cruising speed is 54 m.p.h. The car is manufactured in England by the Grantham Productions Ltd. and will be manufactured in France.



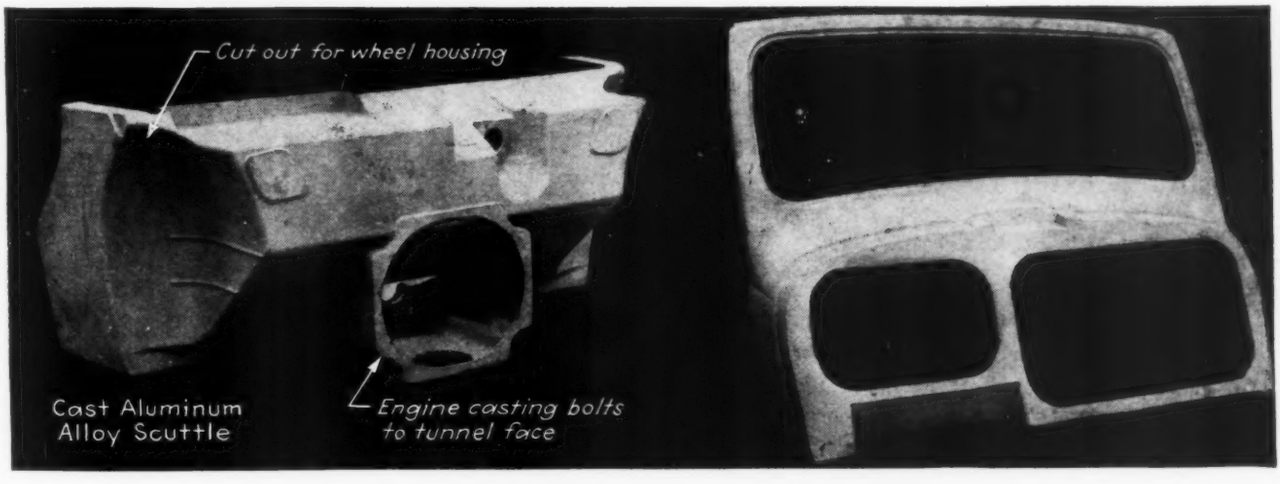


Front fenders, apron and grill, supported on a tubular steel subframe bolted to the scuttle, can be removed as a unit. Details on the aluminum alloy are:
Chemical composition:

DTD 424 Specification	Percent
Silicon	5
Manganese	0.7—0.87
Magnesium	0.1—0.17
Iron	0.8
Copper	3
Nickel	0.35
Zinc	0.2
Titanium	0.14—0.15

Stress Strain Data:
Ultimate stress (untreated) 9-10 tons per sq. in.
Ultimate stress (treated) 18-20 tons per sq. in.
Elongation (untreated) 2 percent
Elongation (treated) 1 percent

Treatment Process:
Solution treat for 5 hr. at 510 deg. C. Quench cold water. Age 8 to 10 hr. at 160-165 deg. C.



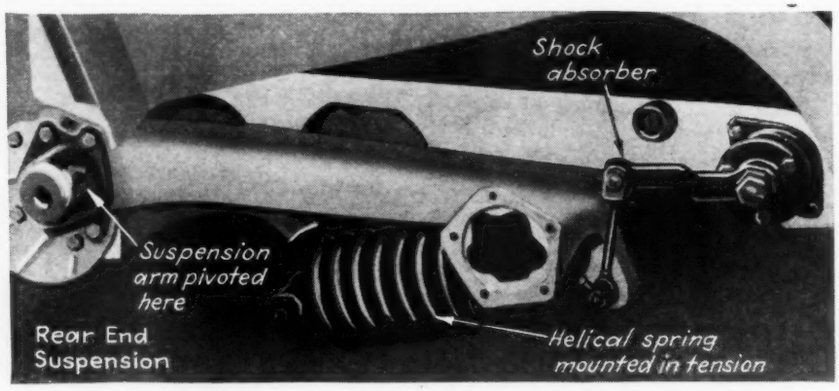
Main supporting member of the frame is the scuttle. The engine mounting casting is secured to its front face. The tunnel in lower half of the casting houses the gear box. **Windshield frame** and dash mounting bolt to top of scuttle.

Two side members act as normal chassis side members. The lower internal flanges locate the flooring, upper internal flanges support the front seats. Seats are adjusted by removing two positioning bolts and inserting them in the alternate locations in the frame. Side member sections have high inertia and are reinforced with strengthening ribs.

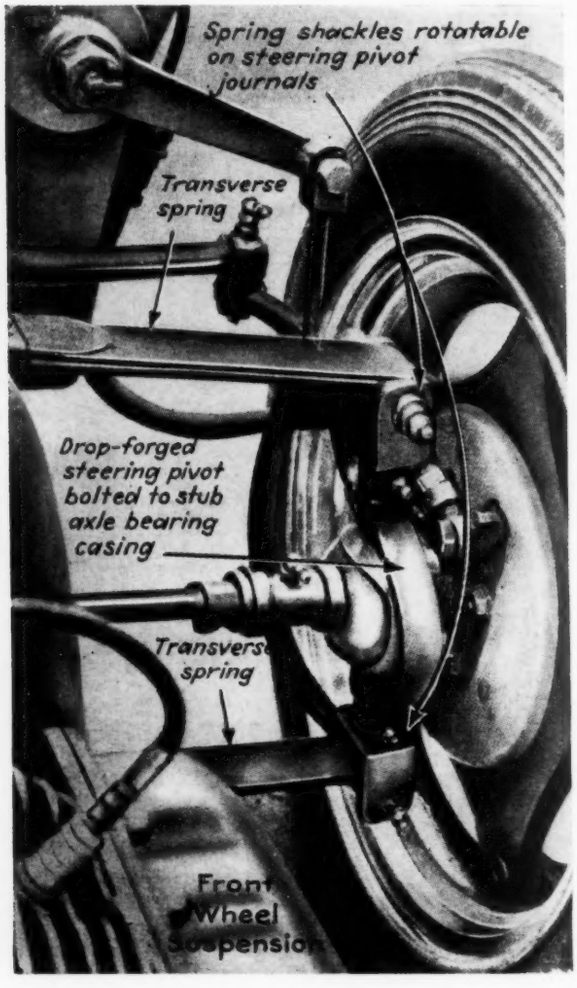
(Continued on next page)

Aluminum Automobile (continued)

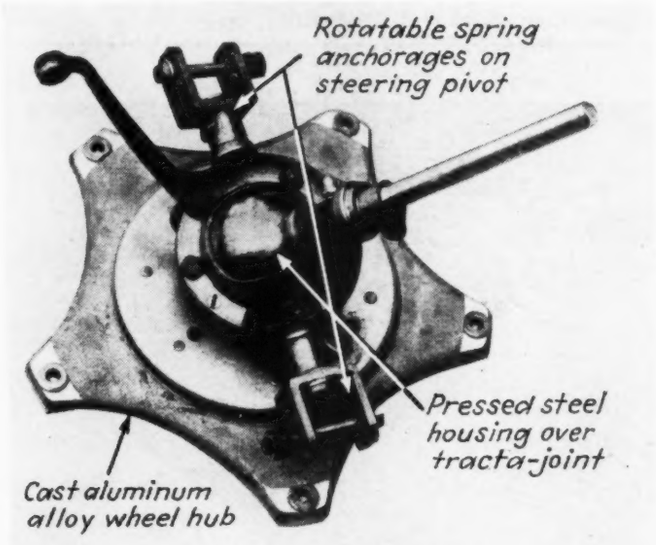
All four wheels are independently suspended and have hydraulic shock absorbers. Front end suspension consists of two parallel transverse laminated springs anchored to shackles mounted on the journal of the steering pivot. These shackles rotate to provide for steering movement.



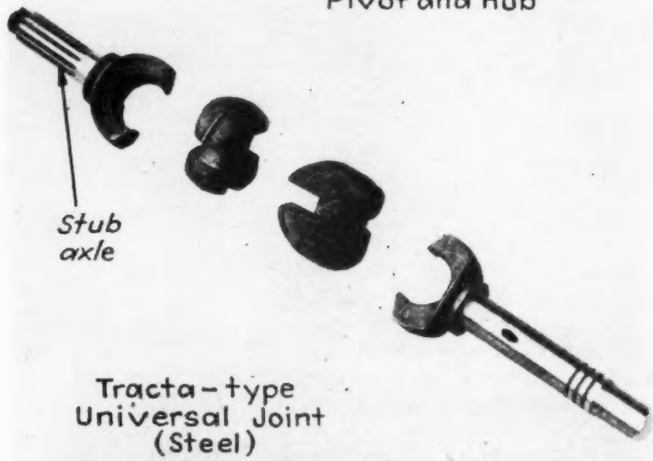
Rear wheels are mounted on stub axles bolted to the rear of the aluminum alloy suspension arm. The suspension arms are pivoted in the pivot housing in the front end of the rear side members. Helical springs working in tension are anchored between rear side members and the suspension arms.


Spring shackles rotatable on steering pivot journals
Transverse spring
Drop-forged steering pivot bolted to stub axle bearing casing
Transverse spring
Front Wheel Suspension

Drive from axle shaft to stub shaft is transmitted by Tracta-Homokinetic joints. This is one of the three designs that was used in the front end drive of the Jeep. The axle is mounted in a double ball or taper roller bearing housing, inclosed in a pressed steel casing that is secured to the aluminum alloy wheel hub. The load is not taken by the axle shaft, but by the wheel hub. Axle shaft breakage will not deflect the wheel position at any speed.

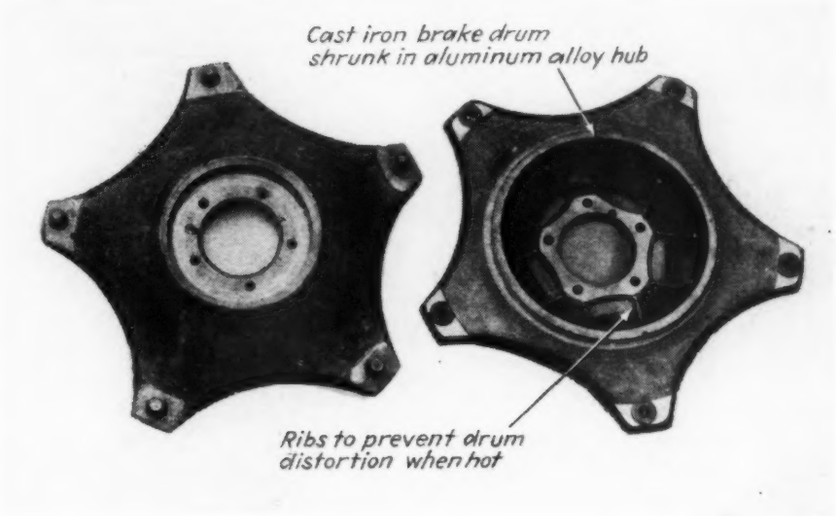


Front End Steering Pivot and Hub

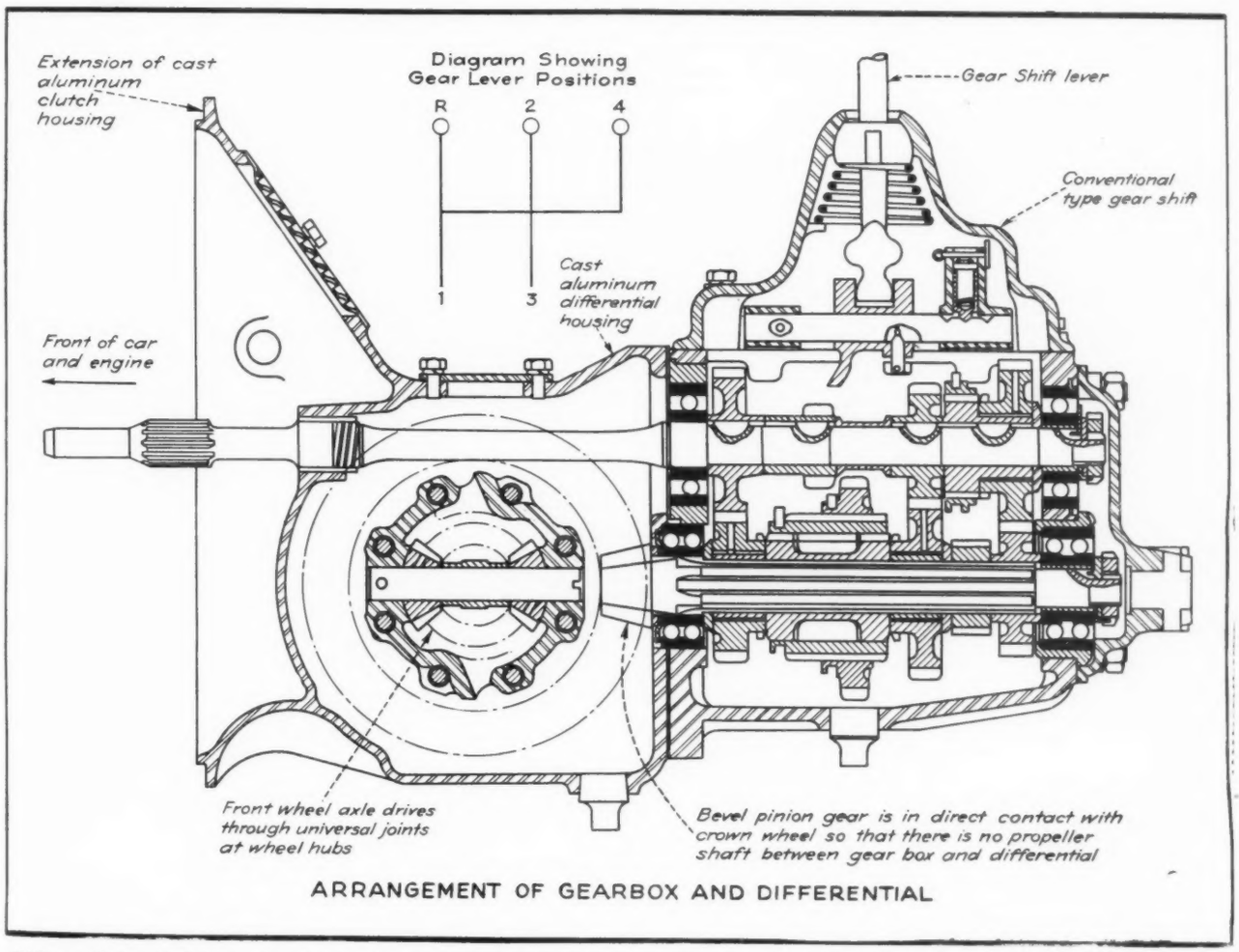


Tracta-type Universal Joint (Steel)

This design was used on the front end drive of some Jeeps



Special cast iron brake drums are shrunk into the cast aluminum alloy wheel hub. The boss of the wheel hub has strengthening ribs to prevent drum distortion. Aluminum alloy wheel rims are detachable from the wheel hub. This arrangement is economical in weight and servicing costs. The front brakes are hydraulically operated; rear brakes are mechanically operated. The pedal controls the front and rear brakes through a bar mounted on a swivel. Its action balances the braking effort. The dual system was used to give greater braking effect on the front rather than rear wheels, because weight is concentrated in the front.

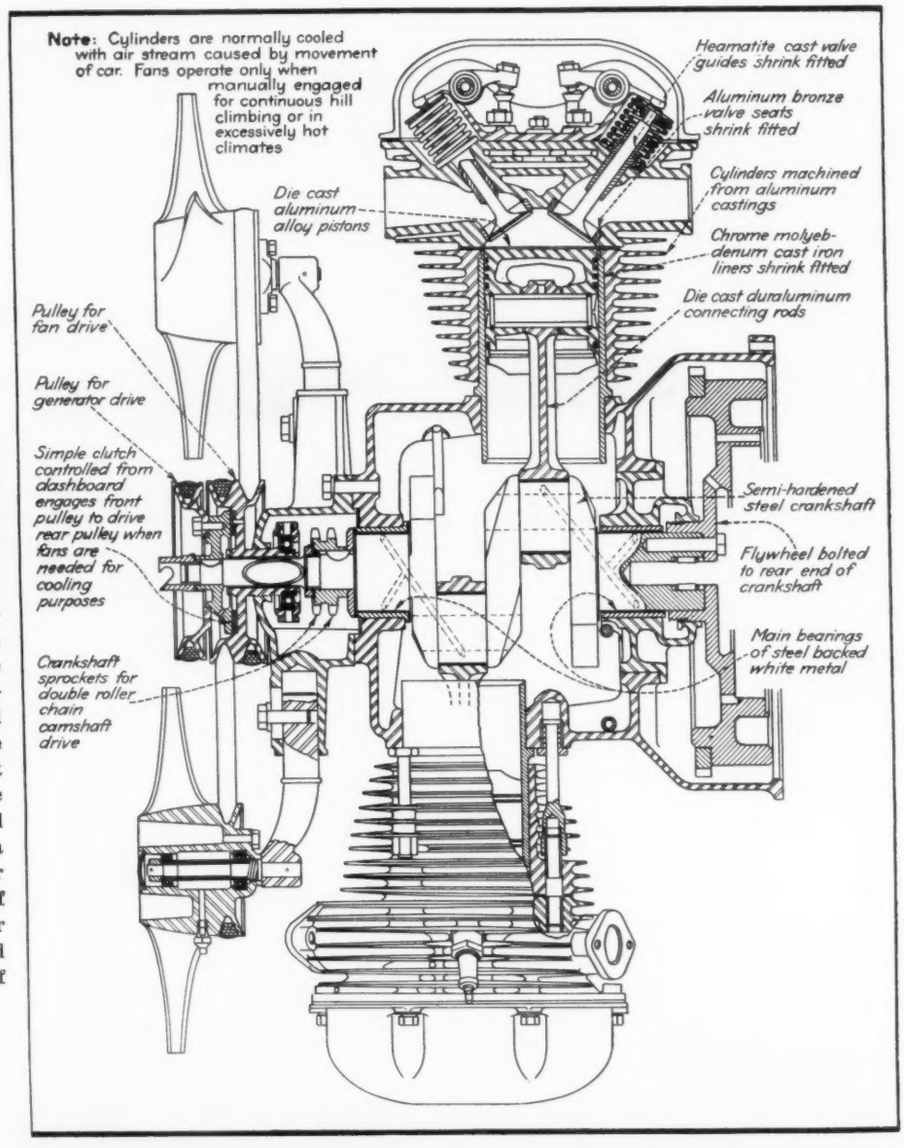

Extension of cast aluminum clutch housing
Diagram Showing Gear Lever Positions
R 2 4
1 3
Gear Shift lever
Conventional type gear shift
Cast aluminum differential housing
Front of car and engine
Front wheel axle drives through universal joints at wheel hubs
Bevel pinion gear is in direct contact with crown wheel so that there is no propeller shaft between gear box and differential

ARRANGEMENT OF GEARBOX AND DIFFERENTIAL

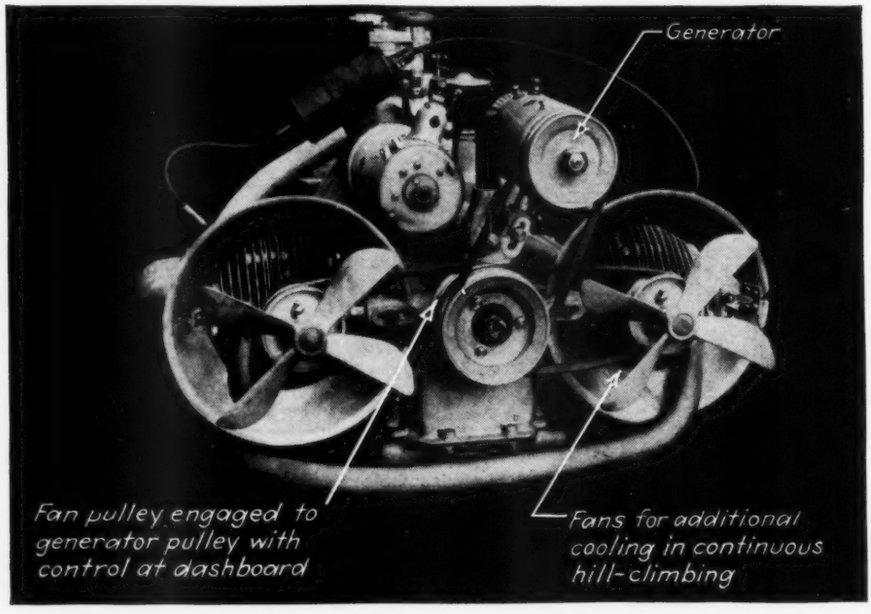
Differential and driving bevels are housed in an extension of the cast aluminum alloy clutch housing bolted to the transmission. Power transmitted through the gear box goes to the output shaft, which drives the ring gear in the differential. The differential lies between the engine and transmission. There is no propeller shaft from the gear box to the differential; the pinion on the output shaft of the gear box is in direct contact with the ring gear on the differential. Engine, transmission and differential, weighing 200 lb., joined as a unit, can be removed in an hour. Axle universal joints are near wheel hubs.

(*Continued on next page*)

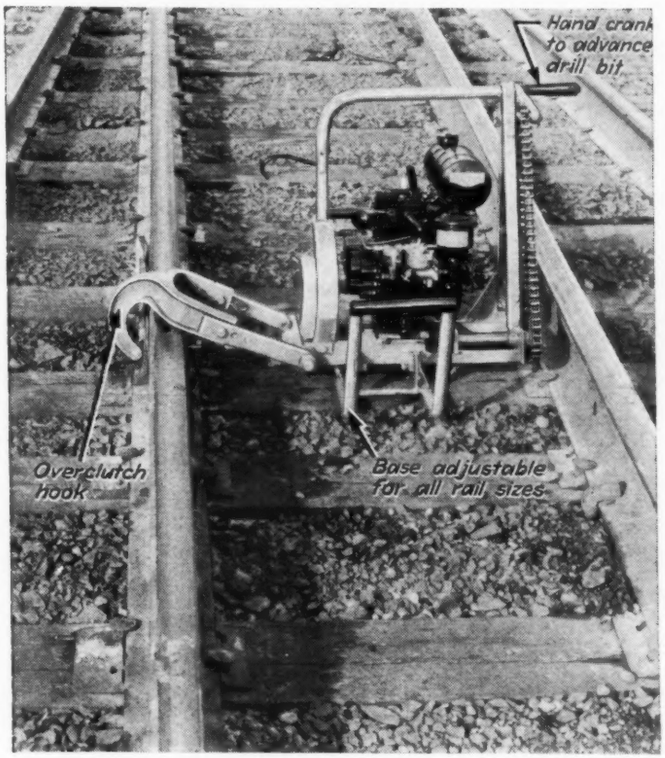
Aluminum Automobile (continued)


Note: Cylinders are normally cooled with air stream caused by movement of car. Fans operate only when manually engaged for continuous hill climbing or in excessively hot climates
Hematite cast valve guides shrink fitted
Aluminum bronze valve seats shrink fitted
Cylinders machined from aluminum castings
Die cast aluminum alloy pistons
Chrome molyb-denum cast iron liners shrink fitted
Die cast duraluminum connecting rods
Pulley for fan drive
Pulley for generator drive
Simple clutch controlled from dashboard engages front pulley to drive rear pulley when fans are needed for cooling purposes
Semi-hardened steel crankshaft
Flywheel bolted to rear end of crankshaft
Main bearings of steel backed white metal
Crankshaft sprockets for double roller chain camshaft drive

Cylinders are machined from aluminum alloy castings fitted with shrunk-in molybdenum cast iron liners. High thermal conductivity of the aluminum assists in rapid dissipation of heat through the cooling fins. A double roller chain is used to drive the camshaft. The camshaft, in turn, drives the overhead valves, the oilgear pump and the distributor. Steel-backed white metal bearings are located front and rear in the crankcase. The flywheel is bolted to the rear end of the crankshaft and carries a gear ring to engage the starter motor pinion. Connecting rods of die cast duralumin have a greater rigidity than a steel connecting rod of comparable weight, because of the larger cross-section.


Generator
Fan pulley engaged to generator pulley with control at dashboard
Fans for additional cooling in continuous hill-climbing

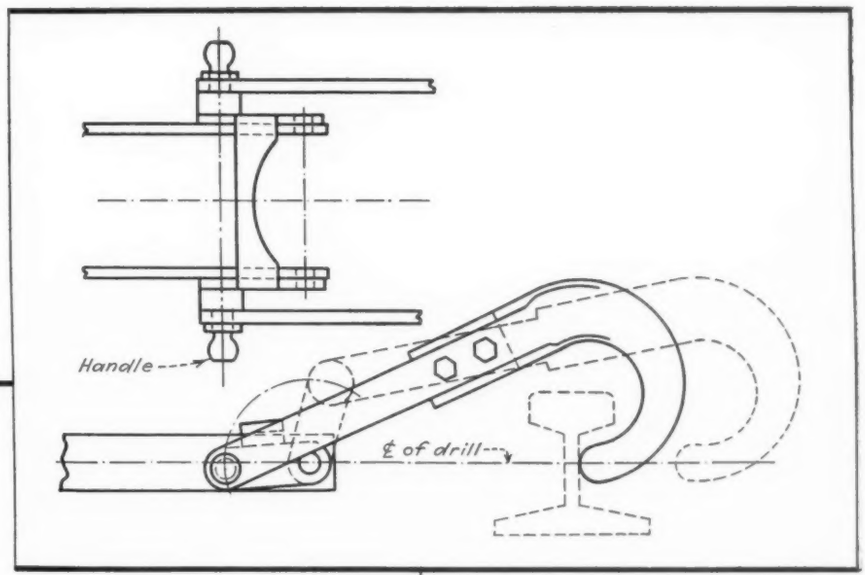
Two V-belt pulleys are mounted on the forward end of the crankshaft to drive the generator and fans. Under normal running conditions the cooling of the engine is adequately maintained by the air stream. The fans operate when engaged to the front pulley by a simple clutch. Fans are used in hot climates or for continuous hill climbing. The downdraft type carburetor incorporates a hot spot.

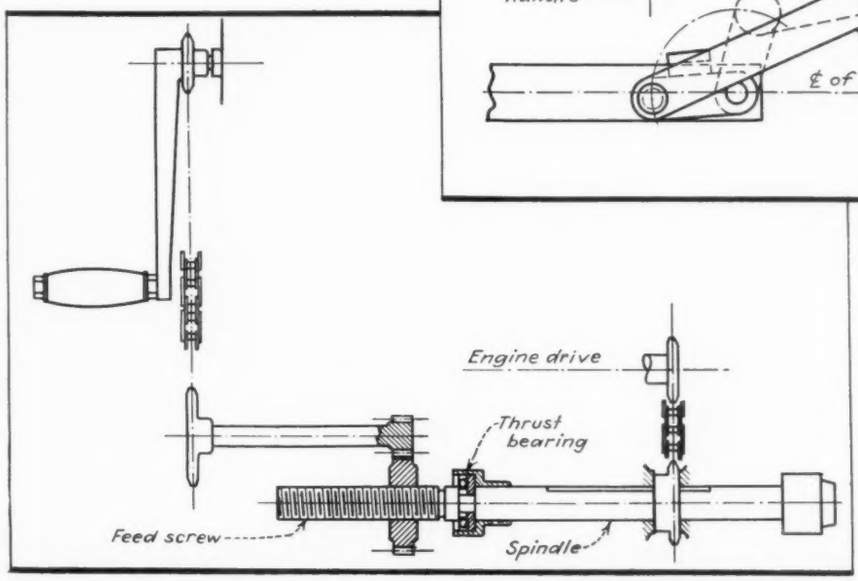


Overclutch Hook Speeds Track Drill Release

CAPABLE of drilling 1 1/8 in. holes through standard 90 lb. rail in 30 sec., the Buda Power Track Drill is manned and moved along the track by one operator. The frame is of a welded construction of mild steel sections. Gears and sprockets are alloy steel, hardened. A 1 1/2 hp. air-cooled engine drives the spindle chuck that takes bits from 3/4 to 1 1/2 in. diameter. Feed of the drill bit is controlled by a hand crank. The drill is built by the Buda Company of Harvey, Ill.

Overclutch hook is released with a single upward movement. The drill can be removed from the track in ten seconds without backing off the bit.

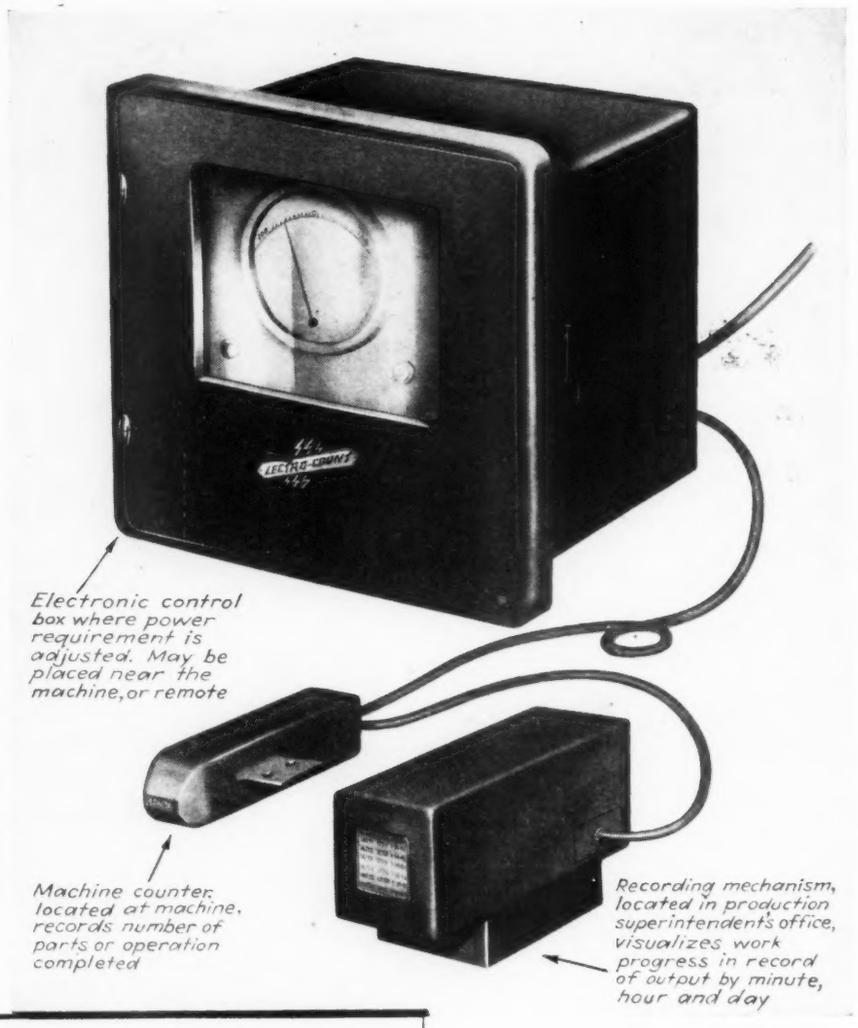


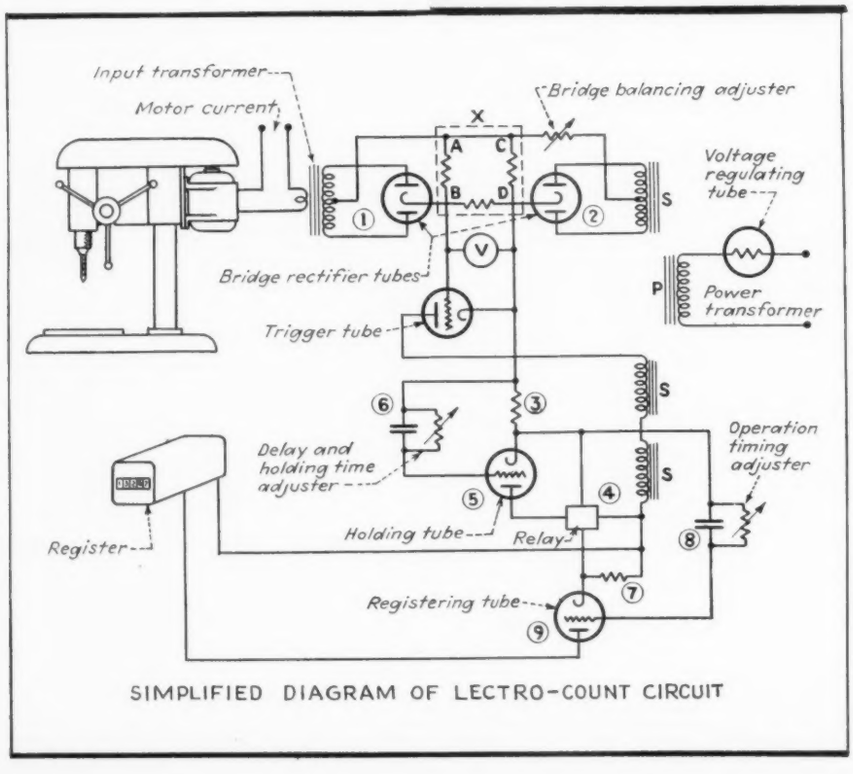


Hand feed of the drill bit is accomplished through a hand crank, chain drive, and feed screw. Thrust from bit is transmitted through a thrust bearing to feed screw. The drill spindle slides through the drive gear as the feed screw advances the bit.

Changes in Load Current Record Performance

BY ELECTRICALLY coupling a machine's current supply to an electronic counter, the instrument is actuated to indicate the number of times the machine performs a specific operation. If the current increase between idling load and productive work load is 1/4 amp. or greater, the device will function. The electronic counter can be set to operate only when the complete load current is drawn. The operator cannot fake the work cycle as is possible with many mechanically actuated counters. The counter known as the Lansing "Lectro-Count" Electronic Counter, is produced by the Lansing Engineering Company of Lansing, Mich.


Electronic control box where power requirement is adjusted. May be placed near the machine, or remote
Machine counter, located at machine, records number of parts or operation completed
Recording mechanism, located in production superintendent's office, visualizes work progress in record of output by minute, hour and day

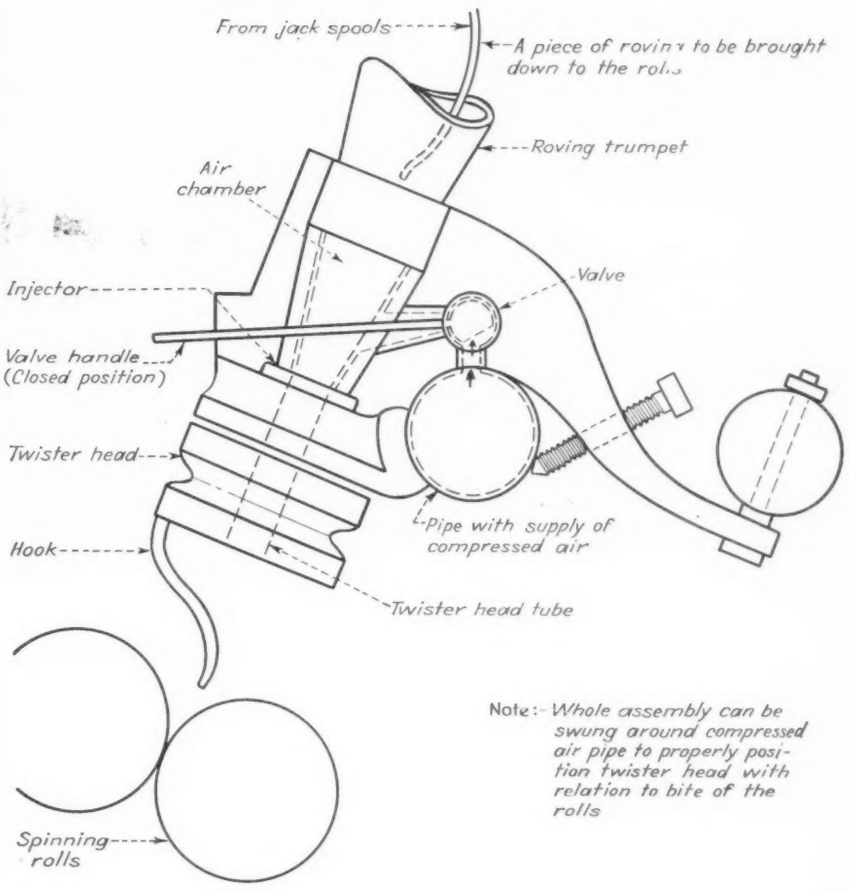


SIMPLIFIED DIAGRAM OF LECTRO-COUNT CIRCUIT

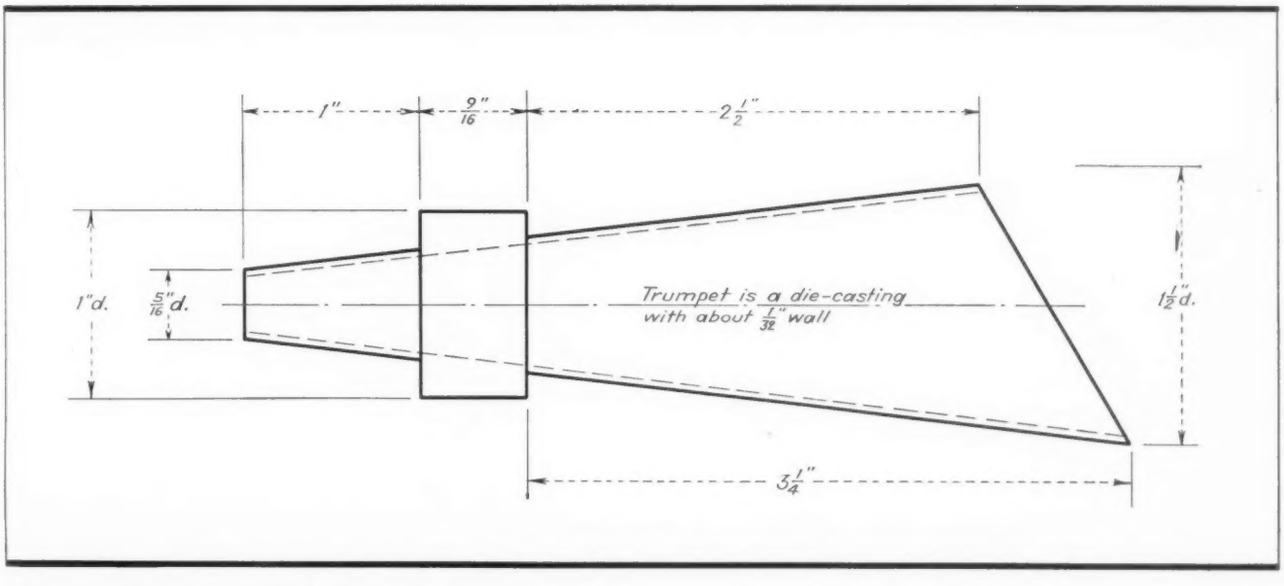
Bridge circuit is adjusted so that when the motor load current increases more than a certain value, the potential of the control grid of a trigger tube is raised sufficiently to cause the tube to conduct a plate current. This plate current actuates the holding circuit to close an operating switch while the plate current is flowing. The holding circuit then stays closed a pre-selected time interval after the trigger tube plate current ceases to flow. The operating switch controls the register circuit. The register circuit can be set to delay operation of the counter and recorder, if used, until the operating switch has been continuously closed for a selected time interval. Thus the various circuits of the instrument can be set to respond only to the desired power load. To count operations of very short duration, the holding circuit is transformed by the gang switch into an initial delay circuit, which prevents recording the starting current surge as a work interval.

Air Injector Threads German Spinning Machine

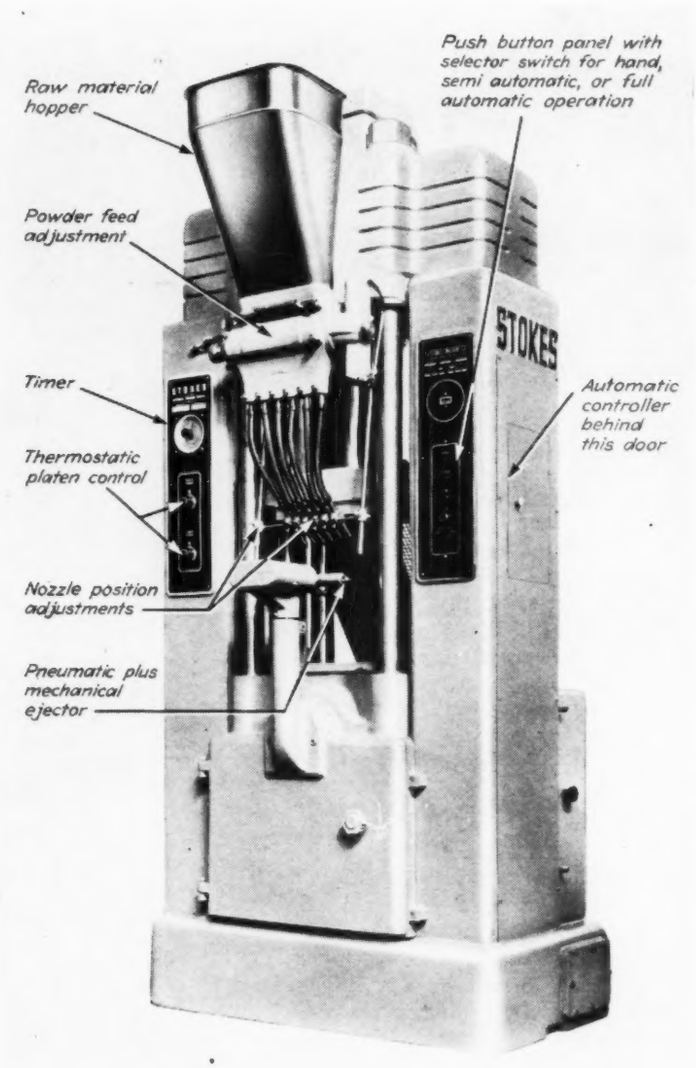
TECHNICAL OBSERVERS in Germany came across a conventional spinning frame that uses a novel method of threading the twister head. The Gessner Ring Spinning Frame for Woolen System differs from American machines in the method of threading the head that leads the roving into the rolls where it is spun into yarn. Twister heads here are threaded with the aid of a common pipe cleaner. The German device uses air pressure. Roving from the jack spool is led into the roving trumpet. When desired to thread the twister head the operator lifts the valve handle (see sketch). As the valve is opened air rushes down through the twister head tube from the cup shaped air chamber. This creates a low pressure in the trumpet nose and causes a current of air to flow through the trumpet bringing the roving with it. The air current continues through the twister head tube and carries the roving into the bite of the rolls.


From jack spools
A piece of roving to be brought down to the rolls
Roving trumpet
Air chamber
Injector
Valve
Valve handle (Closed position)
Twister head
Pipe with supply of compressed air
Hook
Twister head tube
Spinning rolls
Note:- Whole assembly can be swung around compressed air pipe to properly position twister head with relation to bite of the rolls

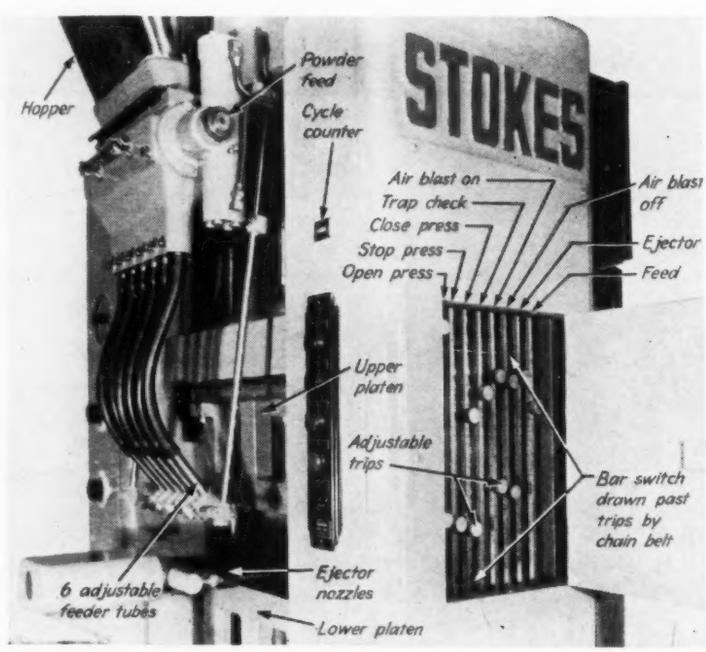
Roving trumpet is a die casting. Twister head and twister tube are made on automatic screw machines and hardened. The air valve is a short ground steel rod, having a flat machined in one side to mate with the air intake hole, and fitted into a reamed pipe. Valve handle is fitted to the extension of the valve rod.



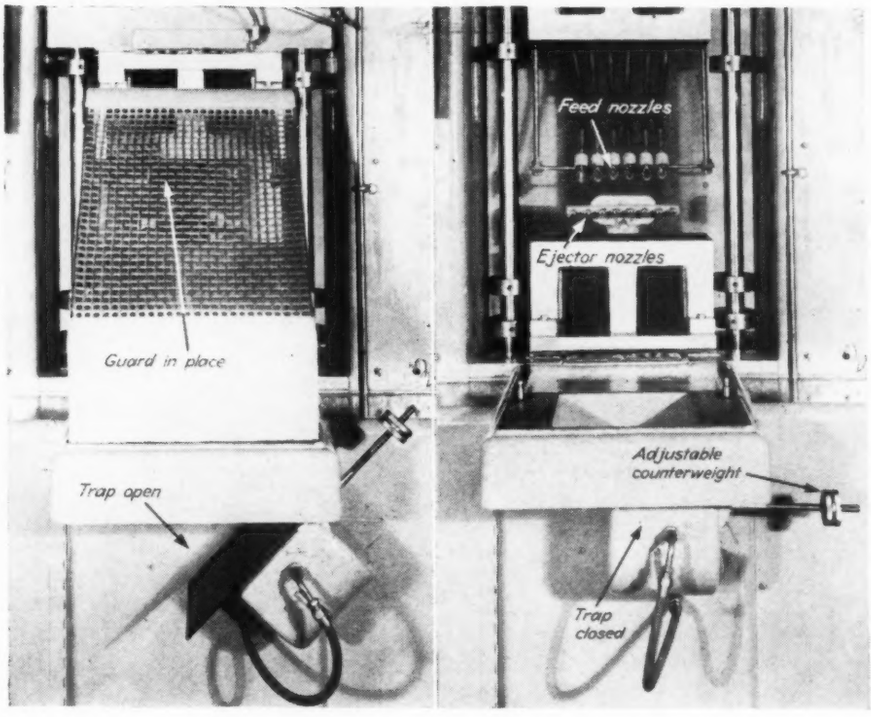
Bar Controller Regulates Automatic Press Molding Cycle


Raw material hopper
Powder feed adjustment
Timer
Thermostatic platen control
Nozzle position adjustments
Pneumatic plus mechanical ejector
Push button panel with selector switch for hand, semi automatic, or full automatic operation
Automatic controller behind this door
STOKES

A BAR TYPE CONTROLLER automatically regulates the entire cycle of this plastic molding press. Feeding, closing, breathing, curing, opening, ejecting and cleaning the mold are adjusted by positioning a series of buttons on the control panel located in one of the press side frames. The other press side frame houses the solenoid air valves, air filter, and alarm bell, and other devices pertinent to the control system. The finished product is checked by a sensitive trap that catches the ejected pieces and stops the machine if the material does not fall within the proper weight limits. Six feeder tubes, individually adjustable for position and capacity, are the means of loading the cavities in the molds. Fast ram action opens and closes the press at 100 in. per min. in the clear. Final compression speed can be regulated between 0 and 8 in. per min. to suit the flow characteristics of the material and the particular mold in use. Pressure can be set between 7 and 50 tons per sq. in. A 3 hp. motor operates the press. Thermostatic controls regulate temperature of the upper and lower electrically heated platens. The 50-ton automatic plastic molding machine is built by the F. J. Stokes Machine Company of Philadelphia, Pa.



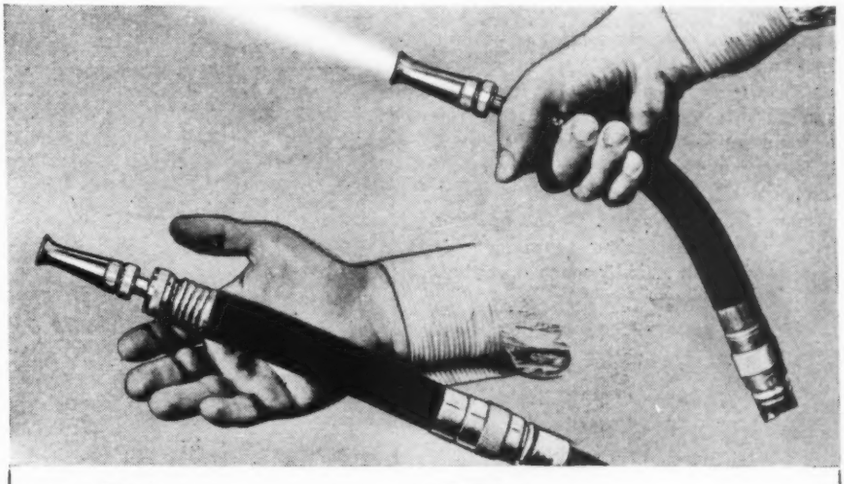
Raw plastic material is fed into the individual feeder tubes the capacities of which are adjustable from ⅛ to 3 cu. in. The feeder nozzles are positioned along a bar by individual wing nut clamps. Cycle controls are readily adjustable by positioning a series of buttons on their respective bars. A chain drive carries a bar trip past these buttons. When contact is made with any button, that part of the cycle is initiated. The multiple feed timer can be set for double or triple loading if required.

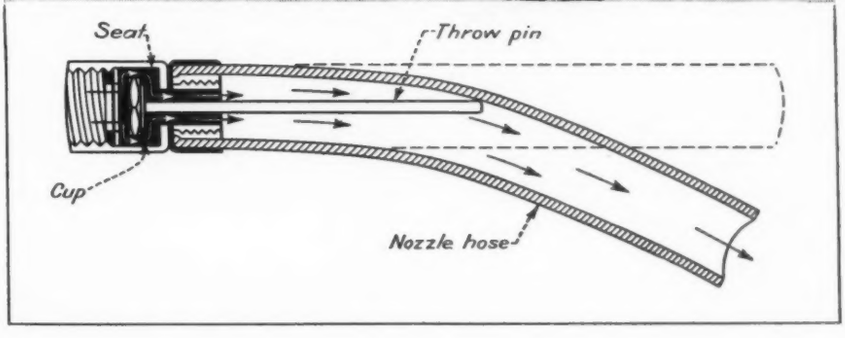


Ejection is accomplished by a combination of mechanical and pneumatic action. When the mold opens, air pressure at 70 to 90 lb. per sq. in. issues from the copper nozzles of the ejector and blows the parts from the mold knockout pins into the trap. If necessary the entire air manifold with nozzles moves forward to bump the parts loose while the air pressure blows them into the trap and cleans the mold. The trap is a platform balance preset with an adjustable counterweight so that if the weight of the ejected parts does not reach the proper value the press stops and an alarm bell sounds. This prevents damage to mold or press and enables one operator to supervise a battery of presses.

Automatic Nozzle for Garden Hose

Complete volume control without screws, springs or levers is achieved in the simple design of the Water Saver Automatic Nozzle. The nozzle has only three working parts and provides positive valve action on low water pressure. The Water Saver is a section of hose containing a throw pin, a cup, and a valve seat. The nozzle shuts off the water when the nozzle hose is straight. As the user grips the nozzle and bends it, water is released in proportion as the hose is bent. It is made by the B. F. Goodrich Company of Akron.

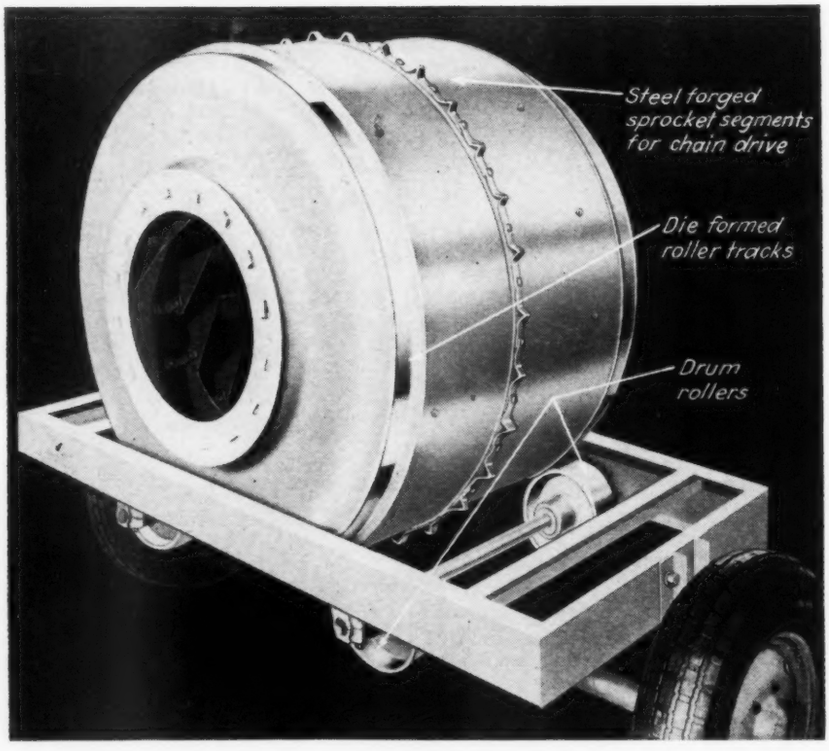




When flexed, the inner side of the nozzle hose pushes on the throw pin. The cup, attached to the throw pin, is forced from its seat allowing the water to flow past it. When the hose is released and permitted to straighten itself out it releases the pin and the pressure of the water in the hose pushes the cup back on its seat thus positively closing the valve.

Compact Concrete Mixer Has Chain Drive On Drum

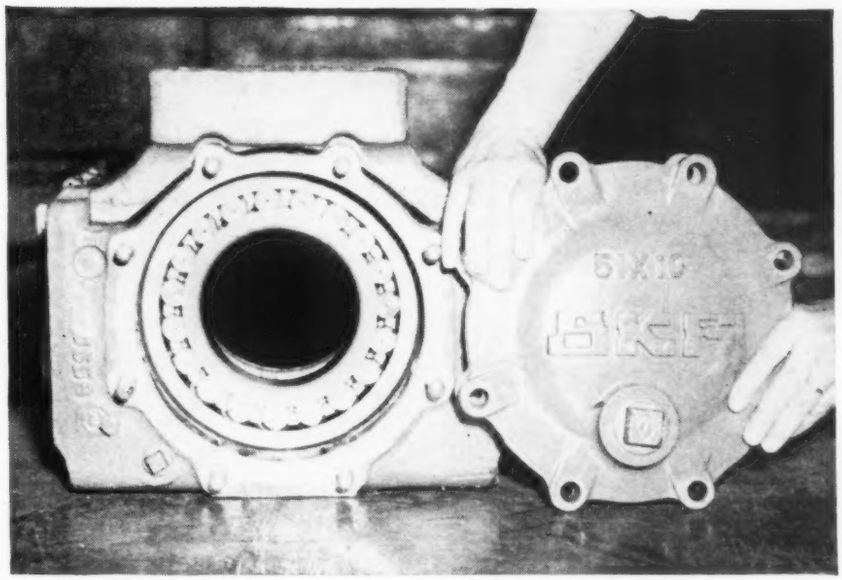
WEIGHT reduction and compact design decreased the height of the Rex 6-S Mixer, developed by The Chain Belt Company of Milwaukee, to 73 in. and lowered the center of gravity thereby giving easy maneuvering. Skip has shaking action activated by shaker rollers (not shown) contacting the wedge-shaped driving lugs on the drum. Bearings on top winding shaft are full floating to prevent binding under skip load. By making the brake and clutch controls independent each can be adjusted without affecting the other. Brake lever and clutch lever to control skip, discharge control, and push-pull type hydraulic valve are handled by the operator from one position. Four adjustable outrigggers give full stability when operating.

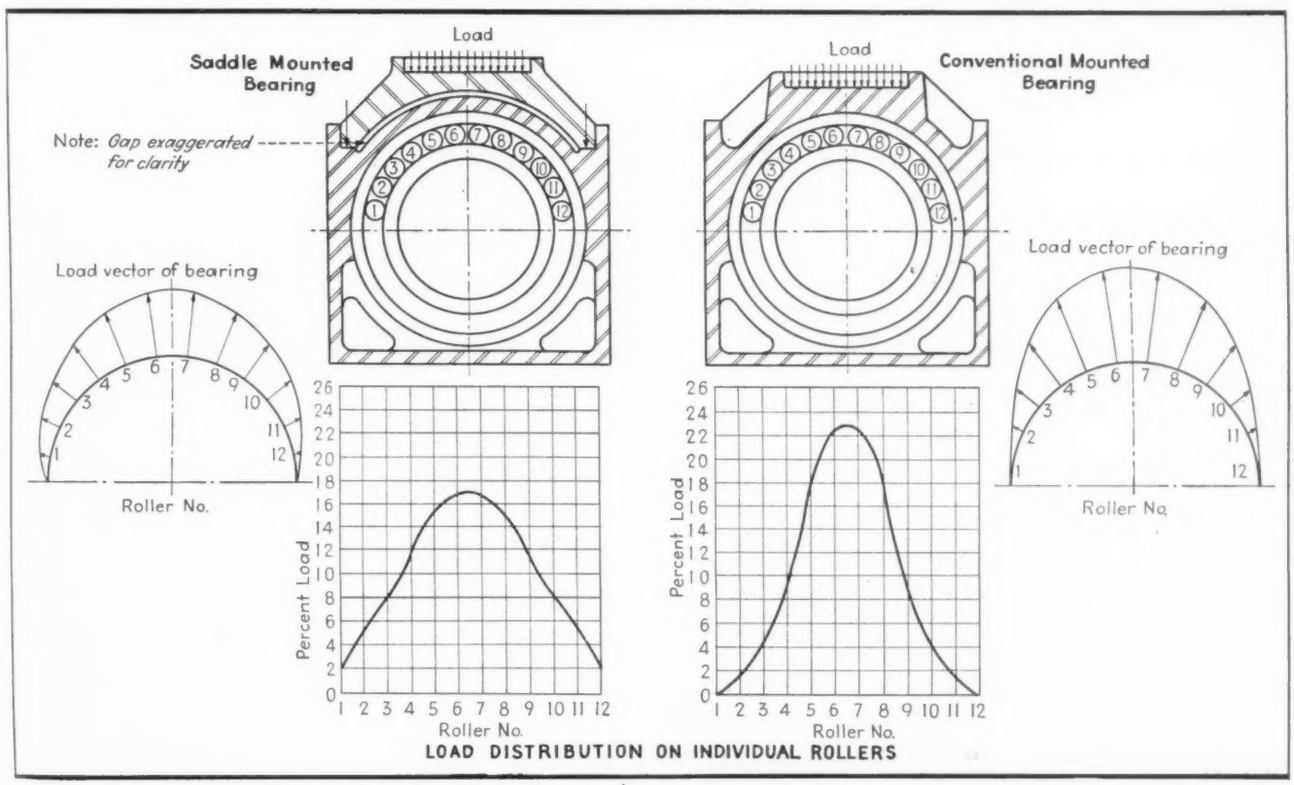


Mixer drum rides on four drum rollers, each mounted on two roller bearings. Tight side of chain drive is on the bottom reducing the load on drum rollers. A two-stage roller chain speed reduction is used between engine shaft and drum drive. Mixer is powered by an aircooled engine; two sizes, 8½ hp. and 13½ hp. are available.

Saddle Mounting Increases Roller Bearing Life

A NEW WAY of applying the load to journal bearings has been devised by the Railroad Department of SKF Industries, Inc., Philadelphia. Studies of the action of service loads on the journal box and bearings disclosed that a more favorable load distribution could be effected by use of a saddle-like device applied to the top of the journal box. Maximum load per roller is reduced approximately 25 percent in the saddle-mounted bearing, as compared to rollers in conventional journal bearings. Endurance tests show an increase in bearing life of about 33 percent.



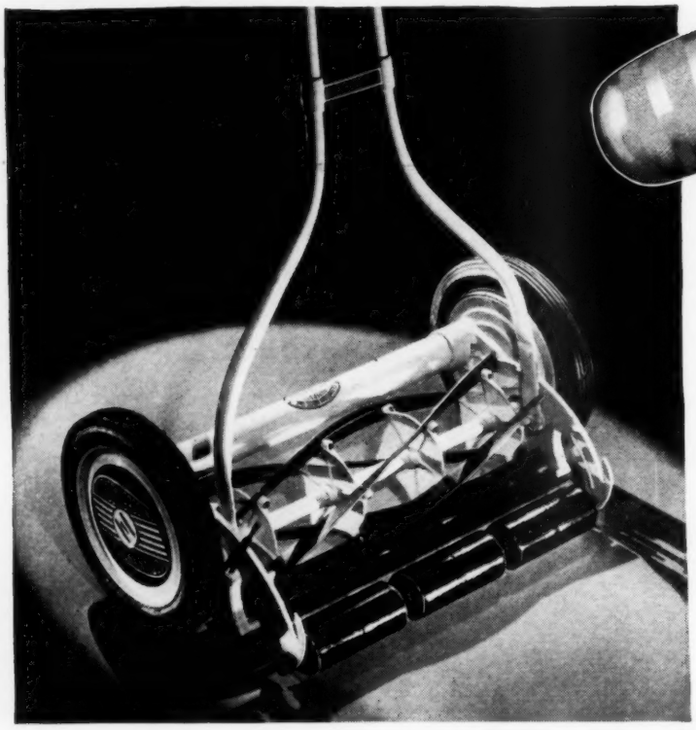


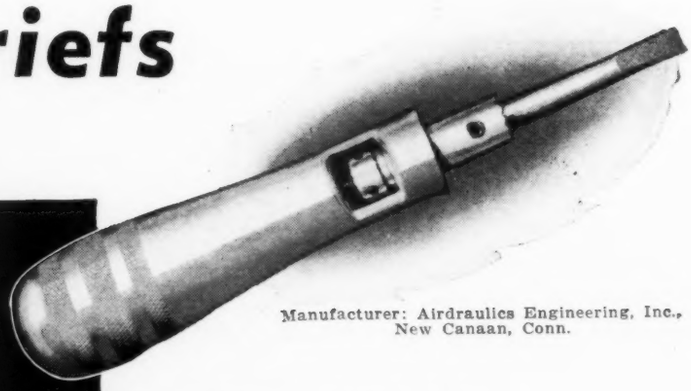
LOAD DISTRIBUTION ON INDIVIDUAL ROLLERS

Previous practice concentrated the loads on a relatively small area on top of the box on the vertical centerline. Regardless of efforts to stiffen this portion of the box, elastic deformations take place that tend to load the few rollers in the top portion of the bearing just under the load. The new saddle design does not introduce these stress concentrations because the load is applied at the sides of the box. The top crown is made relatively flexible and a "wrapping-around" effect of the journal box occurs, thereby distributing the load more uniformly so that the maximum load on any roller is less than with the conventional mounting, thus extending roller life.

PRODUCT DESIGN *briefs*

Manufacturer: Clemson Bros. Inc., Middletown, N. Y.





Manufacturer: Airdraulics Engineering, Inc., New Canaan, Conn.

Torque Screw Driver

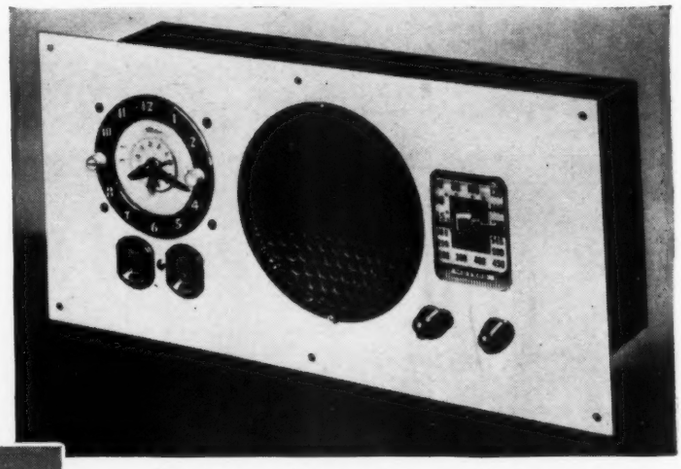
Small light-weight screw driver controls application of torque through a friction disk. Screw driver is preset at the desired torque with a small beam scale. The screw driver is reported to maintain its accuracy within a fraction of an inch pound torque.

Plastic Lawn Mower Roller

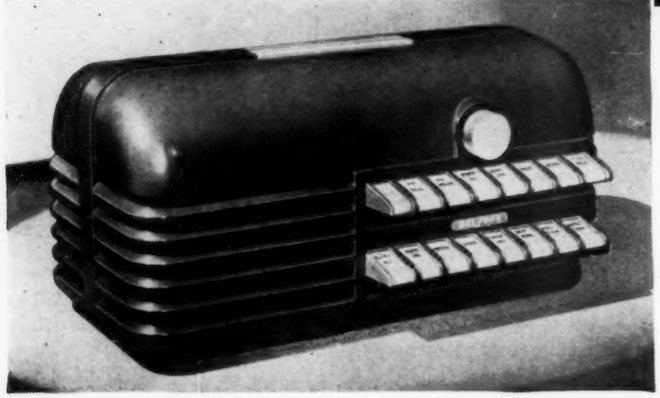
A cellulose acetate roller in three separate sections facilitates changing the direction of the mower without damage to fine sod. Plastic grips, forced over the ends of the tubular steel handle, are said to remain securely in place under vibration. The mower is equipped with rubber tires. Adjustments in cutting height are made by turning a single wing screw.

Intercommunication Unit

Instead of a one-piece housing with open bottom or back, this plant intercommunication unit is housed in a cover comprising a front and a back section. Assembly holes, locating pins and end flanges are molded into these sections. Front and back are then assembled by fitting the molded end flanges in a slot. Rounded top prevents the unit from becoming a catch-all for books and papers that might interfere with proper heat dissipation. The electronic circuit includes a busy signal, and has a circuit for completely private conversations.



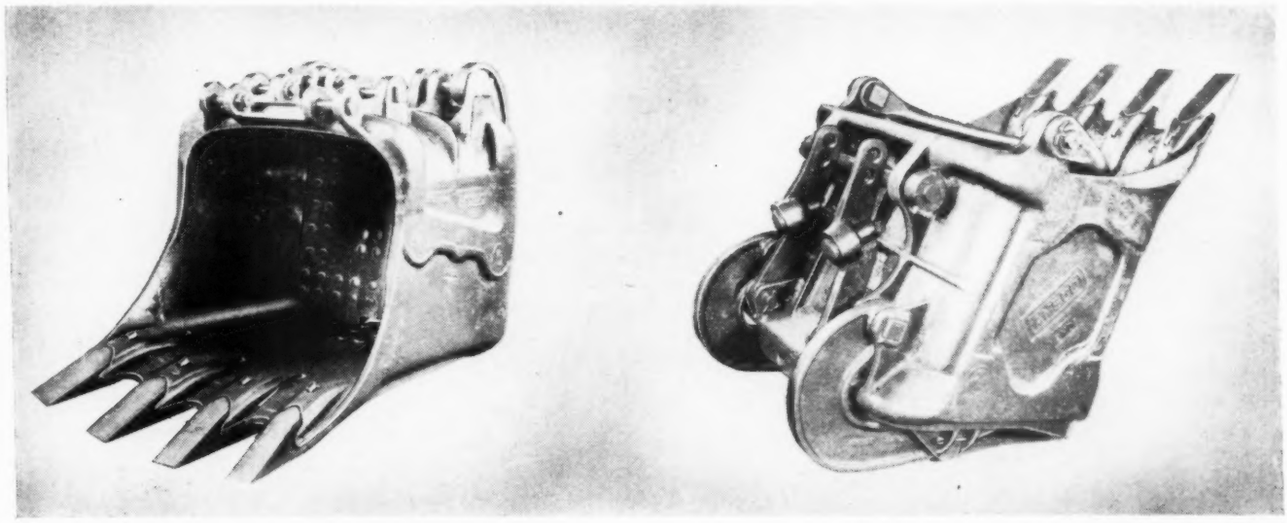
Manufacturer: American Communications Corp., New York.



Manufacturer: Bell Sound Systems, Inc., Columbus, Ohio.

Built-In Wall Type Radio

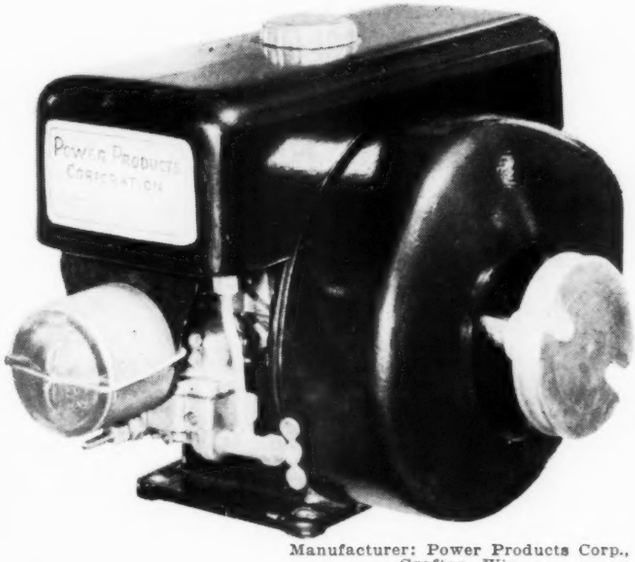
Designed to be built into the walls of homes, the American has interior box dimensions of 4 x 6 x 14 in. Louvers allow dissipation of interior heat. The plastic molded grill can be furnished in colors to harmonize with the walls. A duplex receptacle is convenient for plugging in household appliances. Alarm clock with automatic switch turns the radio on and off at preselected times. The radio has a 6-tube super-heterodyne circuit.



Manufacturer: American Manganese Steel Div., American Brake Shoe Co., Chicago Heights, Ill.

All-Manganese Steel Welded Dipper

Austenitic manganese steel is used in the dipper for maximum resistance to fracture and wear. Overlapping, rabbeted joints leave grooves for the welded beads. Parts are fitted together with plugs around which weld metal is deposited. The body is claimed to be as strong as if it were made in one piece, and yet it is possible to remove a worn front and reweld a new one in place without destroying the back. Three-quarter to 2-yd. sizes are made in two body pieces, front and back. Sizes over 2 yd. are made in four pieces; front, back and two side plates.



Manufacturer: Power Products Corp., Grafton, Wis.

Lightweight Gasoline Engine

Bearings, crankshaft and part of the magneto are the only parts not of aluminum on this single cylinder two-cycle engine. Rated 3/4 to 1 h.p. depending on speed, the engine weighs approximately 16 lb. and occupies 0.8 cu. ft. of space. It is designed for light-weight portable equipment such as lawnmowers, compressors, pumps, flood lights and bicycles. Operation is said to be good at any angle of tilt up to 45 deg. Gas consumption is 0.4 gal. in 3 hours.

Home Freezer

The 6 cu. ft. freezing unit has an outside dimension of 40 in. long, 46 in. high and 28 in. wide. Inner and outer shells are aluminum for easy cleaning. The aluminum cover is easy to lift. Compressor, powered by a 1/5 hp. motor, will maintain temperature at 0 to —5 deg. F. If temperatures rise above normal for any reason a red signal indicator on the front of the box warns of this condition. Weight is 185 pounds.

Manufacturer: Reynolds Metals Co., Louisville, Ky.

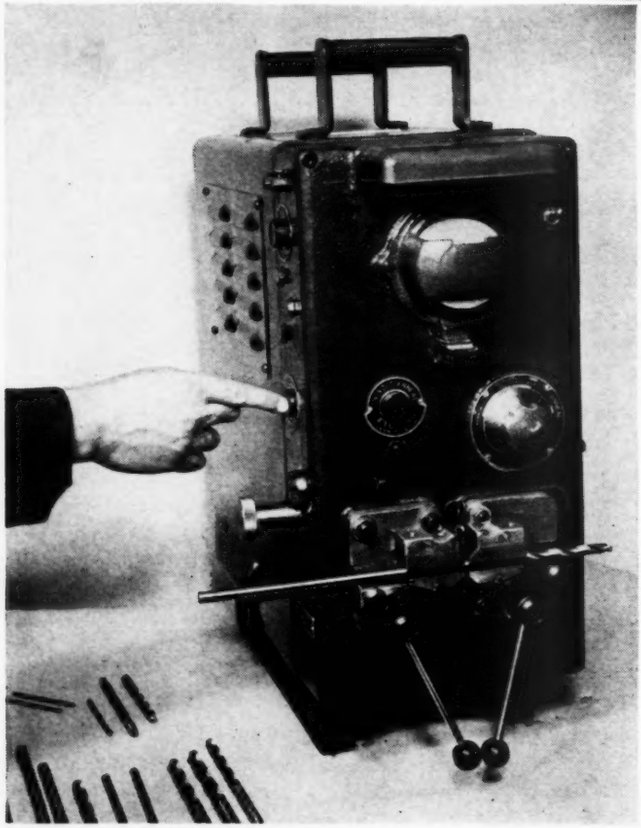
Manufacturer: Landers, Frary & Clark, New Britain, Conn.

Household Scale

Housed in a one-piece zinc die casting finished in white baked enamel, the Super Weigh scale will weigh objects from 1 oz. to 24 lb. Sides and back are built so that the scale can be used flush against a wall or cabinet. The viewing-dial is angled for easy reading without stooping or squinting. A table on the back panel furnishes weight and quantity reference data for use in food preparation and canning. A heavily reinforced baked enamel tray can be attached to the top platform to adapt the unit for use as a baby scale.

Automatic Butt Welder

Completely automatic welder is controlled by a single push-button switch. It is built for production welding of bar and round stock up to 5/16 in. dia. An automatically controlled motor feed is said to assure good welds even with inexperienced operators. The built-in grinding wheel for weld dressing can be seen at the front top of the machine. Cam-operated lever clamps hold the work.



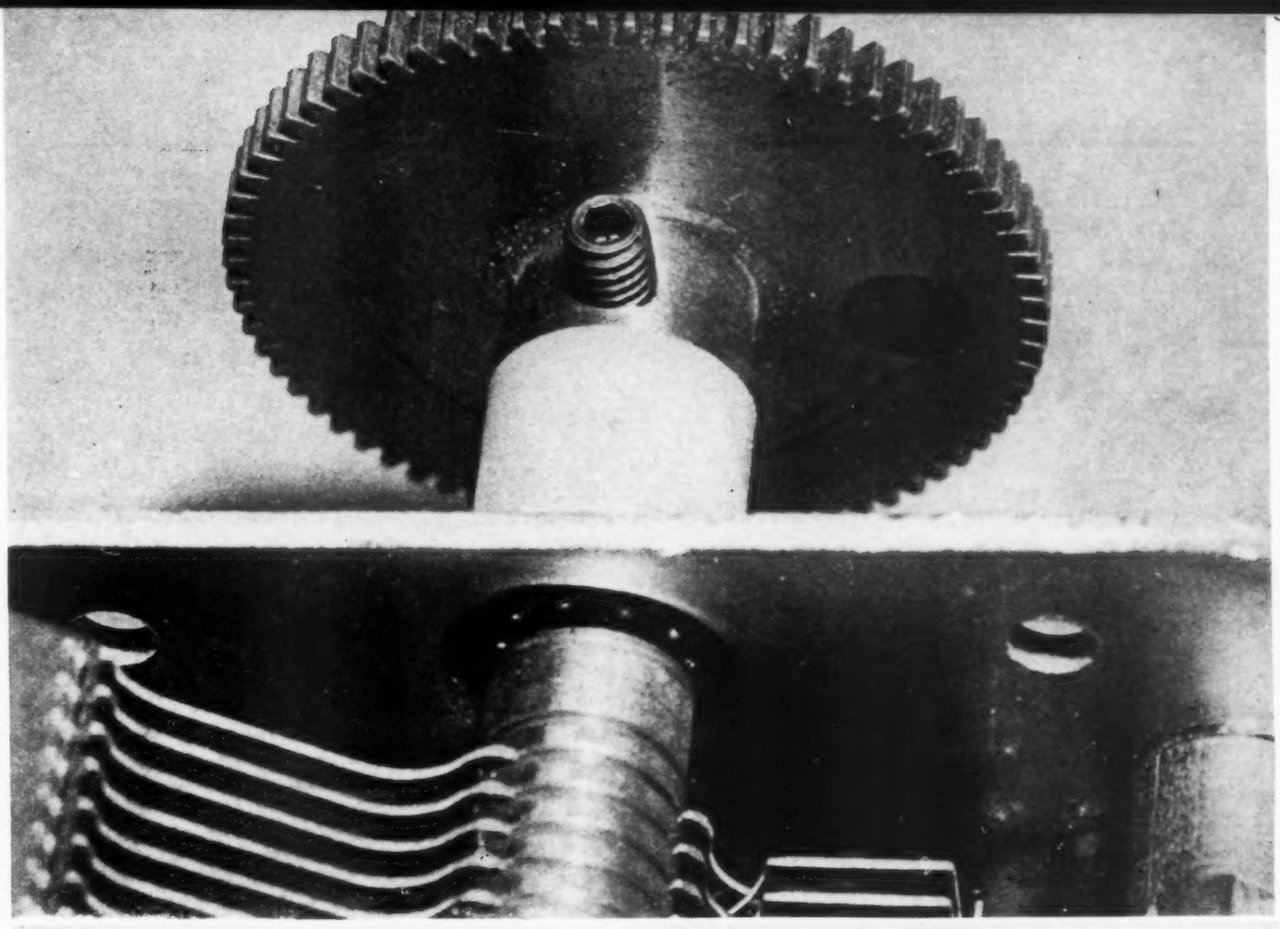
Manufacturer: DoAll Co., Minneapolis, Minn.

Manufacturer: Ellinwood Industries, Los Angeles, Calif.

Professional Recording Machine

Portable 16-in. dual speed recorder has a drive mechanism of the overhead lathe type that maintains speed accuracy to within 0.3 percent at 78 r.p.m. and 0.4 percent at 33 1/3 r.p.m. Positive feed overhead lead screw controls groove spacing, which is variable from 90 to 130 lines per in. Cast aluminum turntable is dynamically balanced. Hardened steel driving shaft supported by two sintered bronze bearings revolves on a single steel ball at the bottom of a 6 in. bearing well. Playback arm, counterbalanced to 3/4 oz., rotates on ball bearings. The pick-up is magnetic. The amplifier incorporates phase inversion, inverse feed back and tone equalization.

HEXAGON SHAPED ROLLS for conveyor systems that carries fabrics into dye kettles have been developed by the Rodney Hunt Machine Company of Orange, Mass. Hexagon rolls are said to be superior to conventional round rolls because they have more pulling power on fabrics and produce a continual shaking that is an aid to better drying. The rolls are of stainless steel, corrosion resistant, and have a smooth surface that will not snag fabrics.



FM-1 nylon shaft extension insulator in place between condenser shaft and drive gear on audiometer. Nylon will hold setscrews and does not develop objectionable electrical leakage at high humidities under low frequency conditions.

Molded and Machined NYLON

LOUIS L. STOTT
The Polymer Corporation

Possessing unusual bearing strength, heat-resistance, toughness and chemical-resistance, molded nylon is available to the designner as a useful industrial plastic. These properties, as well as good moldability and machinability, indicate that nylon is finding application in fields such as bearings, gears, valve seats and in electrical parts.

NYLON is not a specific product, but is rather a family of chemically-related high molecular weight "super polymers," known as polyamides. These materials are used in many forms, such as fibers, filaments, coatings, solutions, and as molding powders in the manufacture of solid objects.

Although technically classed as thermoplastics, in that they can be injection molded and can be ground and remolded, nylon molding powders behave in many respects like a metal. Especially noteworthy is their relatively sharp melting points, at about 505 deg. F. for the FM-1 type, and about 450 deg. F. for FM-3; the older thermoplastics, such as cellulose acetate and the acrylics, enter an indefinite "mushy" range above their softening points.

Nylon molding powders are at present supplied mainly in two formulations: FM-1 and FM-3. FM-1 is used in greater quantities for molded products; FM-3 has only recently become available to the molding industry. Melted FM-1 nylon is extremely fluid for a plastic, having an apparent viscosity approximately that of a light grade lubricating oil. FM-3, a slightly softer and lower melting form of nylon, is used where better moisture absorption properties are desired; the difference in moisture absorption properties of FM-1 and FM-3 are shown in Figs. 1 and 2. This FM-3 nylon is also highly fluid when melted but can be molded in somewhat wider temperature ranges than the FM-1. It is, however, a more expensive polymer.

Most thermoplastics have service tem

Table I—Properties of Molded Nylon[a]

Properties	FM-1	FM-3	ASTM Test Method
Specific gravity	1.14	1.09	D71-27
Tensile strength: —70, 77, 170 deg. F., lb. per sq. in.	15,700; 10,530; 7,600	12,900; 7,600; 6,760	D638-42T
Elongation: —70, 77, 170 deg. F., percent	1.6; 54; 220	2.0; 75; 320	D638-42T
Modulus of elasticity, 77 deg. F., lb. per sq. in.	325,000	——	D638-42T
Flexural strength, 77 deg. F., lb. per sq. in.	13,000[b]	8,200[b]	D650-42T
Stiffness, 77 deg. F., lb. per sq. in.	290,000	152,000	D747-43T
Impact, Izod —70, 77, 170 deg. F., ft.-lb./in.	0.42; 0.94; 0.97	0.27; 1.34;[b]	D256-43T
Rockwell hardness	M 90	M54	D229-43
Flow temp., deg. C.	>250[c]	>250[c]	D569-43
Heat distortion temp., 264 lb. per sq. in., deg. F.	171	132	D648
Heat distortion temp., 66 lb. per sq. in., deg. F.	400	319	D648
Coefficient of expansion per deg. F., linear	5.7×10^{-5}	8.2×10^{-5}[d]	D696-42T
Thermal conductivity — BTU/hr./ft.²/deg. F./in.	1.74	1.0	D325-31T
Dielectric strength — Short time-volt/mil	385 (0.125 in.)	470 (0.125 in.)	D149-40T
Dielectric strength — Step by step-volt/mil	——	410 (0.125 in.)	D149-40T
Volume resistivity, ohm-cm.	4.5×10^{13}	4.1×10^{14}	D257-38
Dielectric constant — 60, 10^3, 10^6, 10^8 cycles	4.1; 4.0; 3.4;-3.24[e]	—; 4.5; 3.55; —	D150-42T
Power factor — 60, 10^3, 10^6, 10^8 cycles	0.014; 0.02; 0.04; 0.036[e]	—; 0.042; 0.031; —	D150-42T
Water absorption, percent	1.5	0.44	D570-42T
Flammability, in 1 min.	Self-extinguishing	Self-extinguishing	D635-41T

[a] Source: E. I. DuPont de Nemours & Company
[b] Specimen did not break.
[c] Exceeds limit of apparatus.
[d] 77 to 140 deg. F.
[e] 0.30×10^8 cycles.

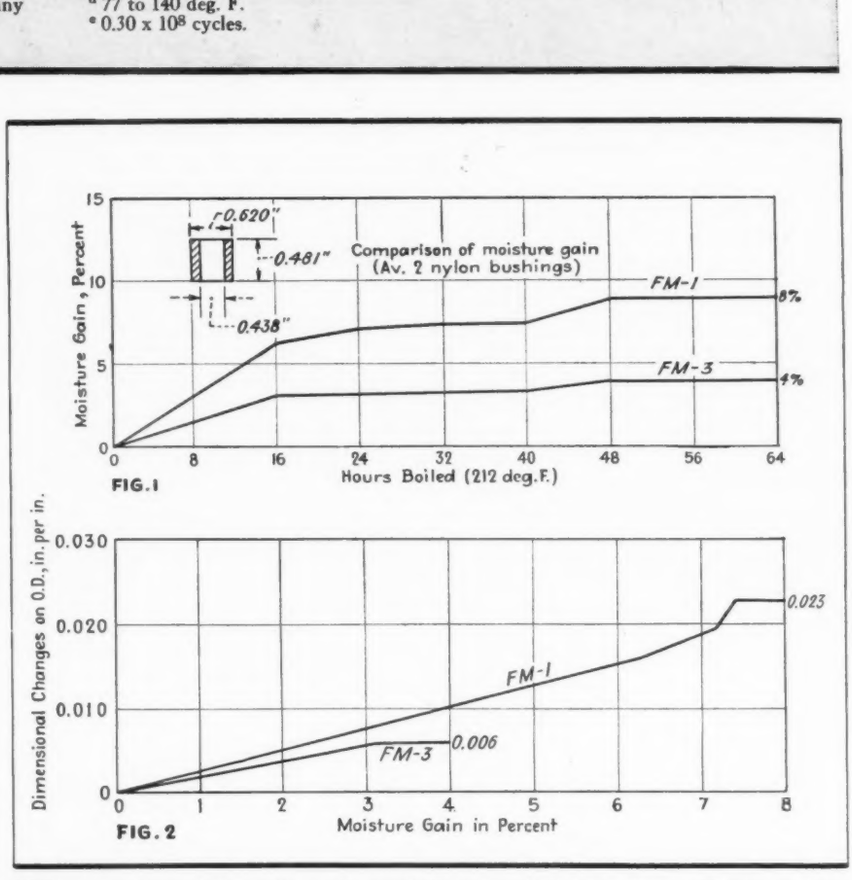
peratures limited to around 160 deg. F. Nylon, especially FM-1, does not soften until temperatures well above 300 deg. F. are attained. This approximates the charring points of some thermosetting materials. Other nylon plastics, having even higher softening points are being developed.

In addition to high heat resistance, nylon offers advantages in toughness, high tensile strength and other physical properties. These are shown in Table I. Chemical resistance is another strong point of nylon. Besides having low water absorption, nylon is inert to virtually all organic acids, carbon bisulfide, halogenated hydrocarbons, carbon tetrachloride, trichlorethylene, alkalies (sodium hydroxide), soaps, gasoline, benzene, benzine, aldehydes, ketones and alcohols. The exceptions are formic and carbolic acids, these being solvents for molded nylon.

Molding

The high fluidity of melted nylon, coupled with a tendency to oxidize when molten, makes necessary close temperature control in handling, and somewhat complicates adaptation of this material to some of the usual forming techniques, such as compression or transfer molding. With minor design modifications of heating chambers and nozzles, as shown in Fig. 3, nylon can be readily injection molded.

The designer should place nylon molding jobs with a molder who is thoroughly experienced in handling this material; there is no other thermoplastic where this is quite so important. Not only is precise temperature control of the molding operation important, but the amount of moisture in the nylon flake must be held to close limits in order to obtain desired properties. To be certain of getting satisfactory moldings, a designer should specify that the injection molded product conform to ASTM specification D789-44T.



Difference in moisture-absorption of FM-1 and FM-3 nylon. Fig. 1—Moisture gain of FM-1 and FM-3 nylon. Fig. 2—Dimensional changes caused by moisture gain.

Many nylon products, however, are made by machining standard molded shapes. Made by a special process that is a combination of molding and extrusion, round rods are available in diameters from $\frac{1}{8}$ in. to 2 in. A limited range of strip and slab sizes can also be made. An efficient combination of molding and machining can be calculated by the design engineer if he consults the molder.

At present nylon molding powder is available only in its natural creamy white color and in black. The high temperatures required to mold nylon have made it difficult to color the molding powder. A process for coloring nylon products after molding has been developed, however, and a wide range of colors can be obtained. The dyeing is done by the molder, or the

dye material can be supplied to the user if he prefers to do his own coloring. The color penetrates quite deeply beneath the surface and is resistant to boiling water and abrasion.

Machining

In machining nylon, the highest possible speeds should be used and tools kept sharp. High speed steel or tungsten carbide should be used for best results, and tools should be ground with a large clearance angle. This will avoid rubbing which might be detrimental to the finish, as molded nylon, although dense, has a fibrous structure. There is also a tendency for the piece to push away or spring away from the tool. This is especially noticeable when turning a rod held between centers on a lathe. Even when a travel rest is used there is considerable vibration and whip. It is good practice to use a cooling fluid, hydrocarbons or soap solutions, when machining.

DRILLING. High speed drills should be used, at the highest r.p.m. possible without "gumming" the stock. The drill should be burnished and have deep flutes and plenty of clearance so that it will cut freely and prevent "grabbing."

SCREW MACHINING OPERATIONS. Washers, disks, and other small shapes can be machined from nylon rods either in an automatic or hand-type screw machine. Cutting speeds and feeds should be as high as possible. Cut-off tools with carbide tips will give good results.

THREADING AND TAPPING. For cutting screw threads on nylon rods, self-opening dies with high speed chasers should be used. Fine threads can be cut with a single point tool on a small bench lathe equipped with a threading attachment and expanding collet. When deep threads are required several successive cuts should be made ranging from 0.007 in. to 0.010 in. deep. In tapping holes high speed taps from 0.002 in. to 0.005 in. oversize should be used. A slight chamfer around the edge of the hole before tapping will prevent tearing the thread.

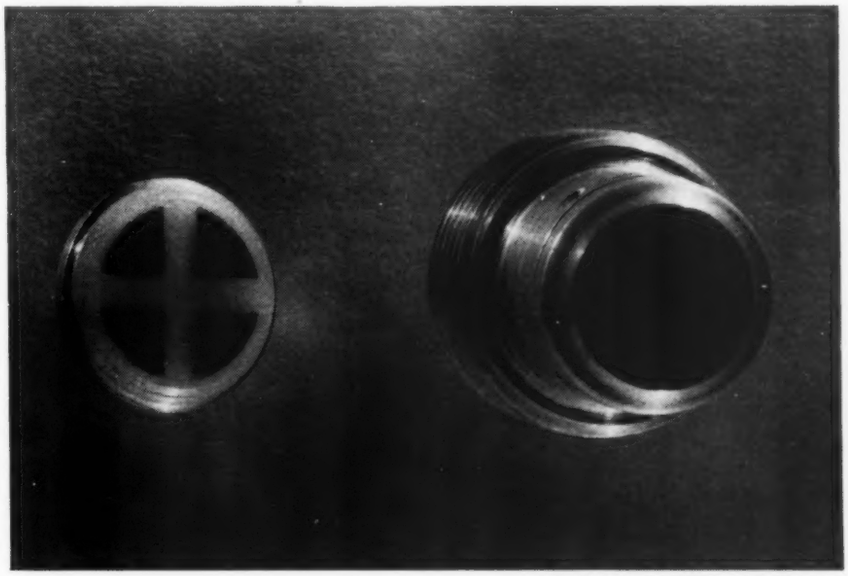
SAWING. Nylon rods can be satisfactorily sawed with a band saw when close tolerance or smooth edges are not imperative. The saw should be kept extremely sharp by frequent filing, and more set is required than for sawing metal.

FINISHING. Nylon can be given a smooth finish by rubbing with a fine grade abrasive cloth and then by buffing with a standard cotton buffing wheel. Rods can be reduced in diameter readily by centerless grinding.

TOLERANCES. The coefficient of expansion of molded nylon in the low-temperature range is much higher than that of most metals. Therefore, when close tolerances are required the dimension should be measured after the piece has cooled.

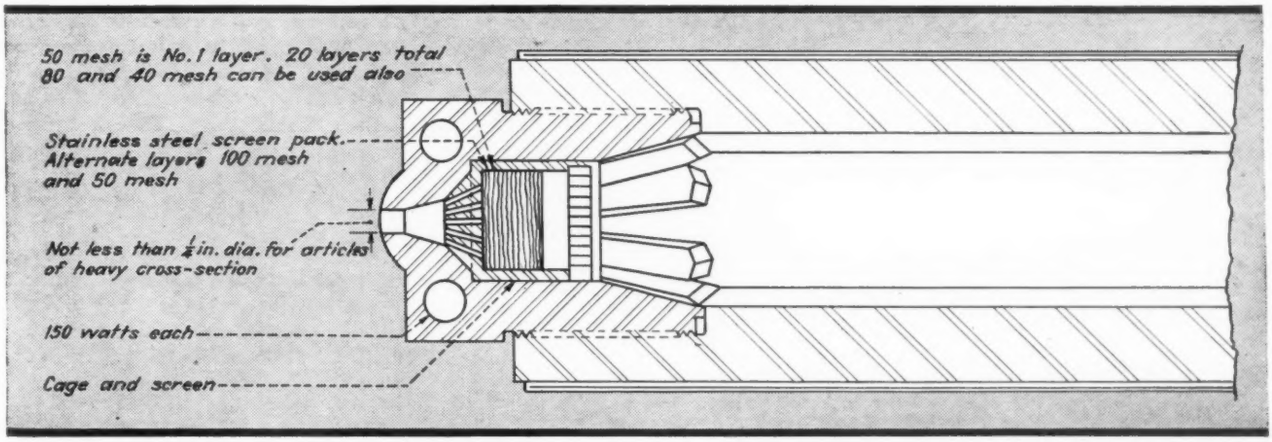
Applications

VALVE SEATS AND SEALS. Molded nylon was used in many war applications which have definite possibilities for peacetime industrial use. One of the first of these was as a stop-valve seat used in Navy torpedoes. The valve seat, Fig. 4, which had to withstand air pressure of 2,800 lb. per sq. in., was formerly made of metal and had to be hand lapped. The nylon valve seat, molded to a metal backing did not need to be lapped. Since nylon is deformable, the presence of dust on the valve seat did not prevent a tight fit when the valve was closed. The nylon valve seat weighed 20 percent less than the metal seat. A direct peacetime result of this ap-



E. I. duPont de Nemours & Company

Fig. 4—Nylon valve seat weighs 20 percent less than old style bronze seat.


50 mesh is No. 1 layer. 20 layers total
80 and 40 mesh can be used also
Stainless steel screen pack.
Alternate layers 100 mesh
and 50 mesh
Not less than ¼ in. dia. for articles
of heavy cross-section
150 watts each
Cage and screen

E. I. duPont de Nemours & Company

Fig. 3—Modifications of nozzle, cage and cylinder of injection molding machines are important for close control of temperature and pressure in molding of nylon. Screens prevent oozing of molten nylon from nozzle.

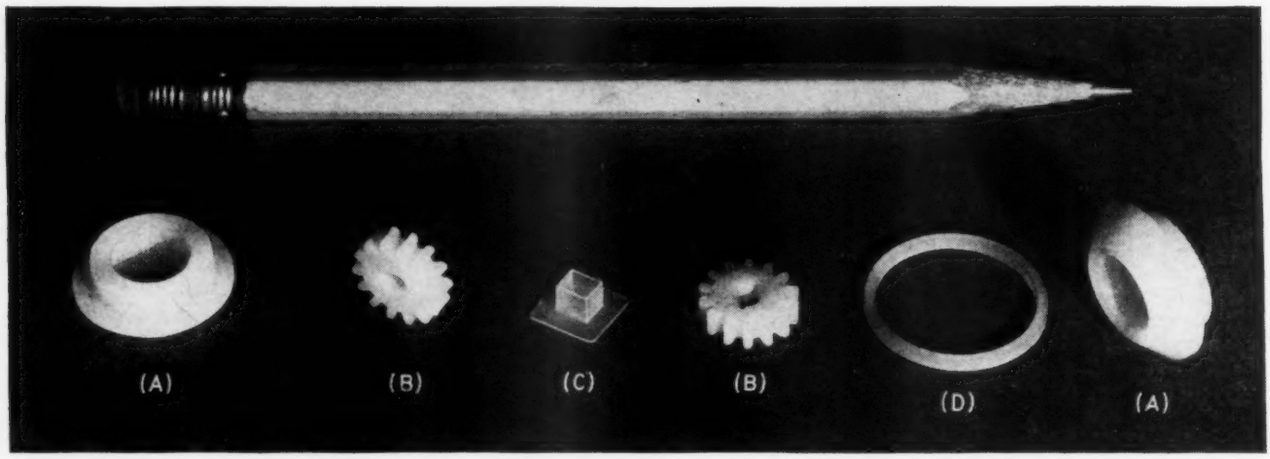


Fig. 5—(A) Compression valve seat in household plumbing devices. (B) Spur gear in aircraft navigational instrument. (C) Coil form in miniature transformer. (D) Nylon washer in bubble chamber of aerial sextant replaced lead washer.

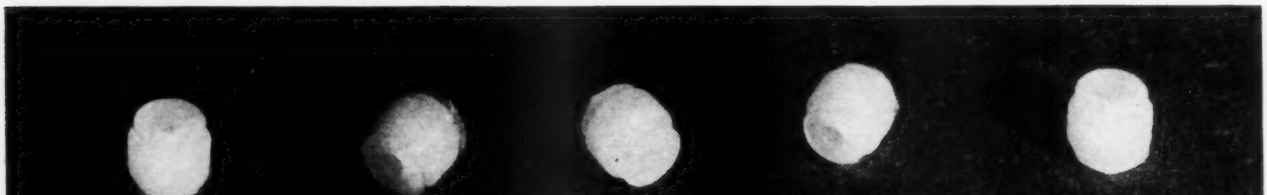


Fig. 6—Insulating bushing used in automotive radio

plication has been the development of nylon valve seats for ordinary household water faucets. A similar part, shown in Fig. 5(*A*), is an FM-1 nylon compression valve seat in a household plumbing device. This piece, although made from rod, may be injection molded in the future.

Another application where nylon proved to be superior to metal was for a sealing washer for holding alcohol in the bubble chamber of an aerial sextant. Lead washers, previously used, reacted with the alcohol, causing discoloration which impaired visibility. Shown in Fig. 5(*D*), an improved washer, having a 1⅛ in. diameter, was molded of FM-1 nylon.

A recent water compression-valve seat, requiring close tolerances, made use of FM-3 nylon rods. The hygroscopic expansion of FM-1 nylon was too high, and FM-3 proved superior in this respect. Tests indicate that FM-3 may be somewhat better than FM-1 for household plumbing uses because FM-3 is a little softer, hence has a better "feel" to the average person.

Nylon valve seats are already being used in CO_2 fire extinguishers, and in oxygen regulators. They are being tried out in many types of air and hydraulic valves, with promising indications.

ELECTRICAL APPLICATIONS. In the electrical field, nylon is finding increasing use. A wartime electrical application of nylon, which has been carried over into peacetime use, is in small coil forms for use in radio earphones and in miniature transformers where space is at a premium. Because of its high fluidity in the molten conditions the FM-1 material could be injection molded into extremely thin sections. One nylon coil form, shown in Fig. 5(*C*), was molded with walls only 0.007 in. thick. These pieces were wound and given a standard varnish bake at 280 deg. F., without detrimental results. Not only was electrical efficiency improved with the thin walls but the minute moldings were free from breakage in handling because of the inherent toughness of the nylon.

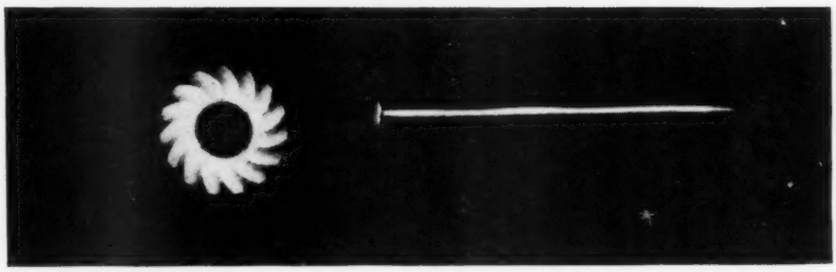


Fig. 7—Small involute gear used in shutter of motion picture camera.

An interesting application now in industrial use is a shaft extension insulator, machined from FM-1 rod, used to insulate frequency control condenser rotors from the drive gear on an audiometer. For this application a material was required which would exhibit practically no electrical leakage after exposure for 30 days to 100 percent relative humidity at a temperature of 98 deg. F., and still be mechanically tough enough to hold small set screws. Contour and dimensional requirements imposed by limited space resulted in rather high mechanical stresses on the insulating shaft. The surface and volume resistance of FM-1 nylon were markedly superior to many other mechanically suitable materials tested for the job.

A development of this application is the nylon insulating bushing, Fig. 6, used in an automotive radio. The piece is placed in a hole in a stamped plate and is then staked in place. It has taken the place of a similar piece made of laminated phenolic, which was unsuccessful because of the high breakage during machining and assembly. Because of close tolerance requirements, this part is being produced in large quantities by machining FM-1

nylon rod on automatic screw machines.

Nylon is being used for wire and cable coverings, sometimes with other plastics. In this application a nylon solution forms a film when applied to the wire. Nylon is adapted to this use by its resilience and resistance to flexural fatigue, in addition to good electrical properties.

GEARS AND BEARINGS. Tests are under way on the use of nylon for gears; it seems to have considerable promise in this field. A small spur gear, Fig. 5(*B*), used in an aircraft navigational instrument, is entirely injection molded. Here wear resistance, toughness and light weight were required. A small involute gear in the shutter mechanism of a motion picture camera, which is subject to considerable shock in starting, stood up better in preliminary tests, when made of nylon, than any other material tried. Shown in Fig. 7, this gear is made from FM-1 rod, and is good example of the machinability of nylon. Silent gears made from nylon are also of interest. One company's investigation indicates less whine at high speeds than reported before. A worm gear, Fig. 8(*E*), is another example of the machinability of nylon rod. Holes for set screws have been drilled and tapped.

The wear resistance and good frictional properties of nylon have suggested its use in the field of bearings. The high molecular weight types, such as FM-1, seem to offer interesting possibilities where oil cannot be used for lubrication. For example, as a substitute for wood in the bearings of textile machinery, nylon shows markedly superior results. In one trial a $\frac{5}{8}$-in. steel shaft was run dry with 0.005 in. clearance against a nylon sleeve bearing $1\frac{3}{8}$ in. long with varying loads up to 400 lb. at 32 r.p.m. After 1,600 hours continuous operation there was very little wear. No tendency at all to squeak was found during the entire test.

In another investigation carried out by an aircraft instrument company FM-1 nylon bearings which had been molded onto steel backs were tried. These bearings were run dry against an SAE 1112 steel shaft of $\frac{1}{2}$ in. dia. operating at 350 r.p.m., using a nylon bearing liner $\frac{3}{64}$ in. thick. Using loads of 200 lb. per sq. in. and a clearance of 0.005 in., these bearings showed no visible wear after 2,500,000 revolutions without any lubrication. Because the thermal expansion of FM-1 nylon is 5.7×10^{-5} per deg. F., or about 10 times higher than steel, and its thermal conductivity is low relative to a metal, the bearing liner should be made as thin as can be properly molded onto a steel back. In this way the necessary clearances can be reduced.

An interesting combination of bearing strength and corrosion resistance is the large black bushing, Fig. 8(*A*). It is used on a plating machine, where corrosive conditions prevent the use of metal bushings.

For the future, the possibilities of molded nylon can be seen from several examples. A small nylon pulley, Fig. 8(*D*), not yet on the market, is injection molded and hand assembled with a metal pin. An oil pressure regulator piston on a diesel engine, Fig. 8(*C*), has been machined from FM-1 nylon rod; preliminary tests have been satisfactory.

Three new formulations of nylon, FM-100, FM-101 and FM-105, are not yet available in commercial quantities. FM-100 was developed for both injection and extrusion, while FM-101 is used chiefly for the solution-coating of bare wire or of wire-carrying a primary insulation. FM-105 is a heat-stabilizezd nylon developed especially for wire-coating.

The latest additions to the nylon family is nylon sheeting, made of a lower-melting formulation, which, because of its toughness, is expected to become a partial replacement for leather; this is only in the experimental stage.

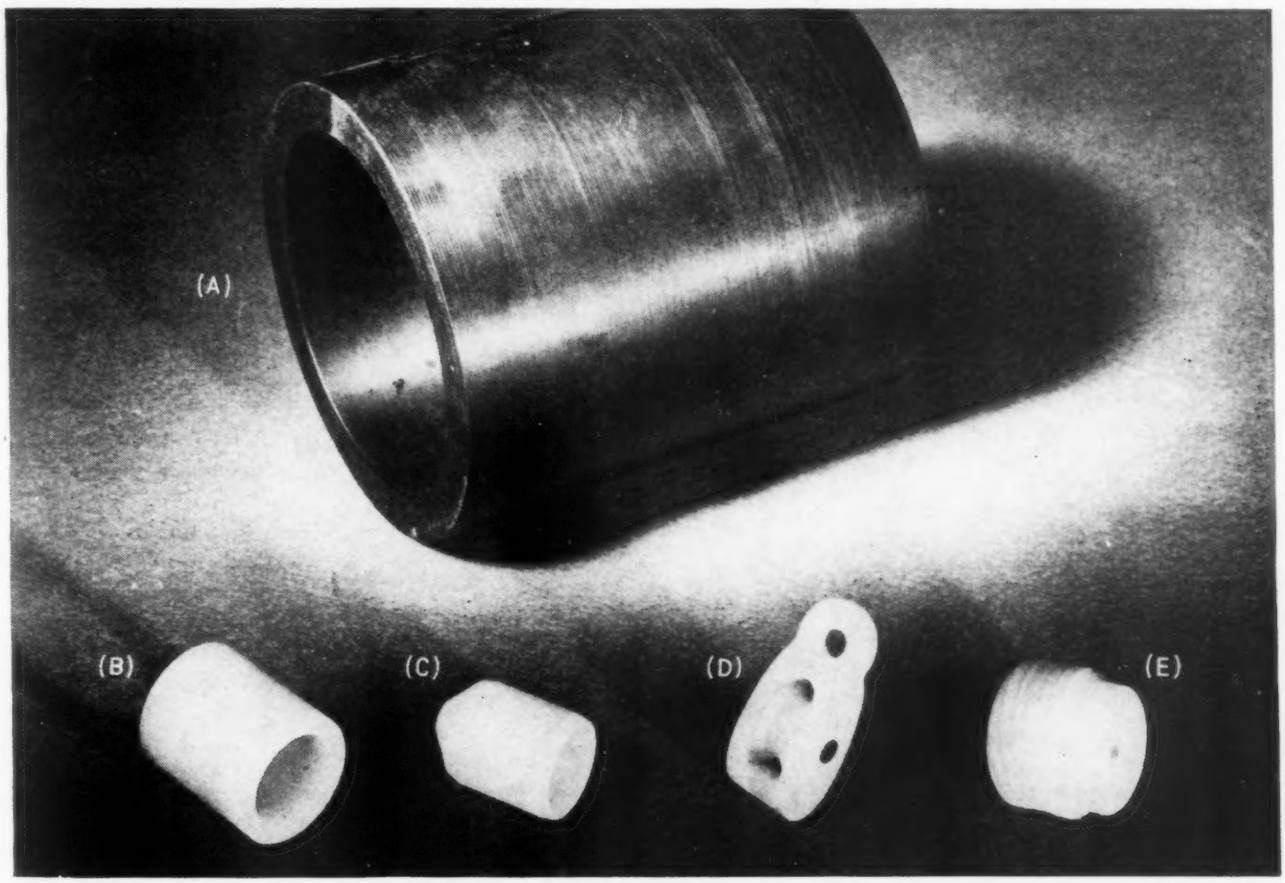


Fig. 8—Typical applications of molded nylon: (A) Large bushing on electroplating machine. (B) Bearing in aircraft instruments. (C) Oil pressure regulator piston on diesel engine. (D) Pulley. (E) Worm gear.

Plates in Tension Joints Under Repeated Loading

H. W. FOSTER
Research Engineer, Lockheed Aircraft Corporation

Effect of the geometry of the joint, the stress-strain properties of the structural material, and the magnitude of the applied loading on the efficiency of plates in tension joints under repeated loading. Graphs are included to illustrate the net area and gross area efficiencies of typical joints under repeated loading.

EFFICIENCY of plates in tension joints under repeated loading may be defined in the same manner as for static loading if a number of cycles to failure is specified. The efficiency is equal to the ratio of the amount of unnotched material necessary to carry a certain external loading for a given number of cycles to the amount of material necessary in a joint to carry the same external loading for the same number of cycles.

Since the efficiency varies widely with both the magnitude of the applied load and the geometry of the structure, no simple relation can be set up to evaluate efficiency for all conditions. This article will be limited to a qualitative discussion of the variables present, with examples for particular types of joints and particular loading conditions.

At a riveted or bolted joint, the ratio of the local stress at the edge of the rivet or bolt hole to the average stress in the plate is a function only of the geometry of the structure for stresses in the elastic range, and can be calculated by the mathematical theory of elasticity or can be determined by photoelastic measurements. This ratio is defined as the elastic stress concentration factor and is here designated by K_t or K_{t_g}, depending upon whether the average stress on net area or the average stress on gross area respectively is used in calculating its value.

The curves in Fig. 1 are plots of the elastic stress concentration factor K_t for different pitches of pin-loaded joints in double shear (see M. M. Frocht and M. N. Hill, "Shear Concentration Factors Around a Circular Hole in a Plate Loaded Through Pin in the Hole", *Journal of Applied Mechanics*, March, 1940). The curves in Fig. 2 give similar data for an unfilled hole in a plate (see R. C. J. Howland, "On the Stresses in the Neighborhood of a Circular Hole in a Strip Under Tension", *Phil. Trans. of the Royal Society of London*, Series A, Vol. 229, 1929). The curves in Fig. 1 are approximately correct for single row bolted or round head riveted joints, neglecting friction and eccentricity. The curves in Fig. 2 are included to distinguish between the case of carrying a load around a hole in a plate and the case of transferring a load out of a plate through a shear attachment. Most joints in practical structures lie between these two cases.

In multiple row joints, part of the load is carried around the holes in one row to succeeding rows, and part is transferred from the plate; hence the determination of K_t for most joints requires interpolation between the two cases.

For the purpose of making such an interpolation another ratio P_r/P_s may be defined as the ratio of the load transmitted per rivet to the load per rivet in the plate at any rivet row. Fig. 3 is a replot of the curves of Figs. 1 and 2 on the basis of gross area together with linearly interpolated curves for different values of P_r/P_s. The use of the curve for a pin loaded plate for riveted or bolted joints neglects the effect of friction in reducing the load transmitted by the fastener, the effect of the eccentricity in single shear joints in increasing the maximum local stress, and the effect of clearance between fastener and hole in increasing the maximum local stress. The use of the curve for an unfilled hole in a plate neglects the effect of a pin in the hole in providing restraint against deformation. Fatigue tests indicate, however, that these curves may be used with reasonable accuracy in the fatigue strength analysis of joints fastened with bolts or round head rivets. Machine countersunk rivets or screws in plates the thickness of which is approximately the same as the depth of countersink, apparently develop values of K_t nearly twice those indicated in Fig. 3.

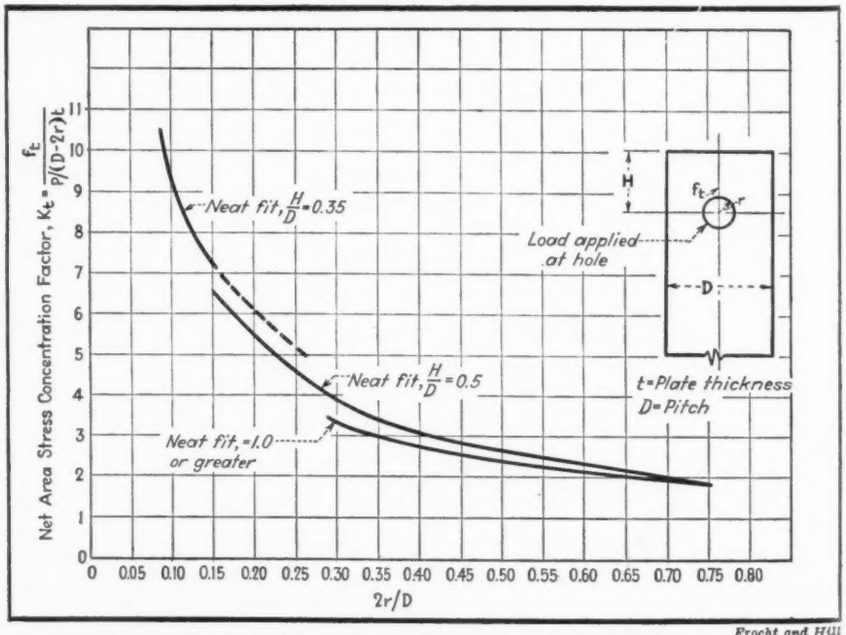


Fig. 1—Values of K_t for pin-loaded joints in double shear.

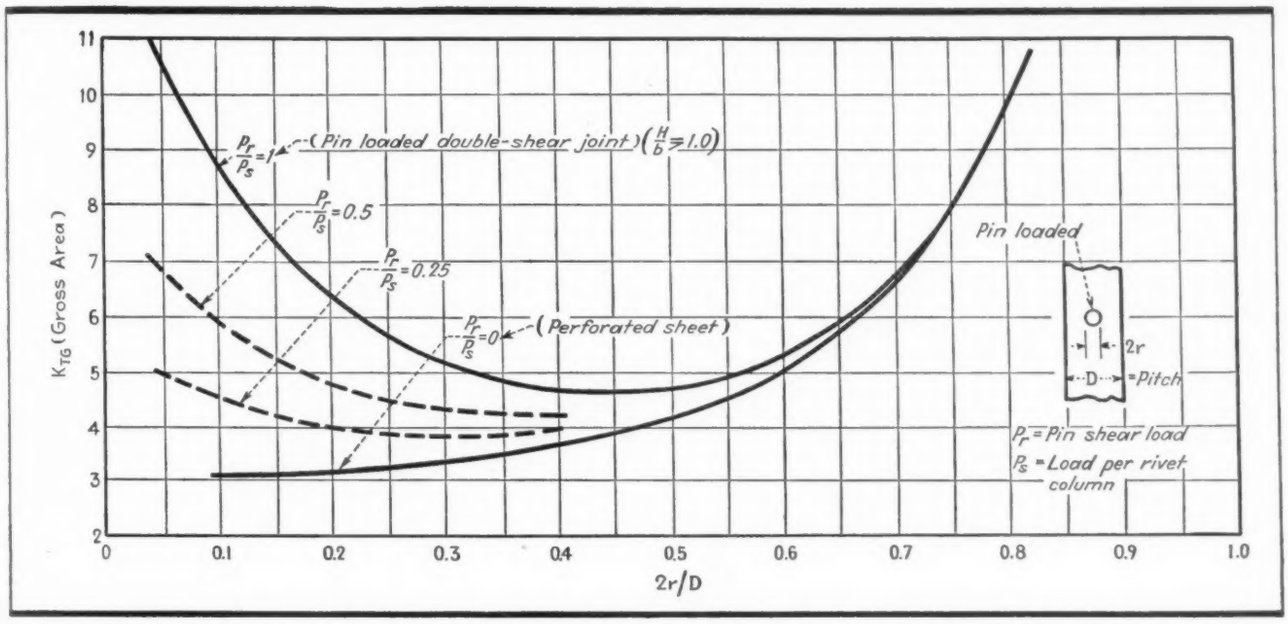
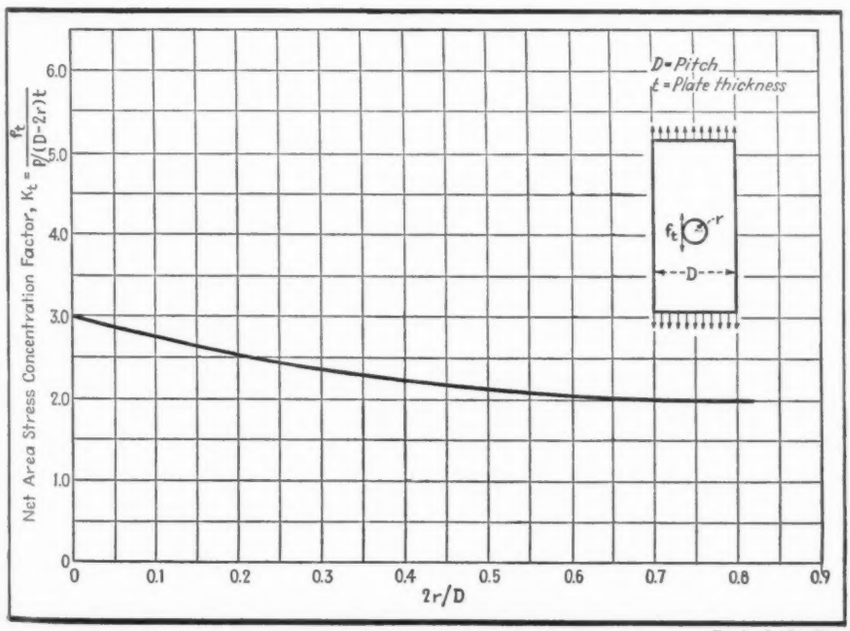


Fig. 3—Elastic stress concentration factor curves interpolated between curve for perforated sheet and curve for sheet with pin loaded in double shear.

The linear interpolation between the two loading cases is an approximation; it checks quite well with fatigue tests of symmetrical double row riveted joints, for which P_r/P_s equals 0.5, but actually the direct superposition of effects would not be expected to be exactly correct since the point of maximum stress is at slightly different position for the two cases. It seems probable, however, that this interpolation is as accurate as the determination of the correct value of P_r/P_s will be for most practical joints.

Since the value of P_r/P_s tends to decrease as the number of rows of fasteners is increased, it would immediately appear that the joint efficiency could always be improved by increasing the number of rivet rows in a joint. But as pointed out by E. C. Posner ("Riveted Fastenings" PRODUCT ENGINEERING, August 1942), the distribution of load among the rivets in a long column may be quite non-uniform unless the joined plates are tapered in such a way that the strain between rivets remains uniform throughout the length of the joint. Therefore, the addition of extra rivet rows may not appreciably decrease the load in the most highly loaded rivet and hence may have no significant effect on joint efficiency.



R. C. J. Howland

Fig. 2—Values of K_t for an unfilled hole in a plate under direct loading.

Since K_{t_g} is the ratio of peak stress to average stress (on gross area) in elastic material, it is the reciprocal of the efficiency factor η, for any part that fails without having become inelastic at the point of maximum stress. Thus, for nonductile materials such as glass, the efficiency is determined practically entirely by the geometry of a joint. Fig. 3 shows that for such materials the greatest efficiency would be obtained in a shear joint when nearly half of the material had been removed by fasteners.

EFFECT OF STRESS MAGNITUDE ON JOINT EFFICIENCY. When a ductile material becomes locally inelastic at the point of maximum stress, the stress and strain distributions change in a manner that reduces the ratio of maximum stress to average stress, that is, the actual stress concentration factor becomes lower than would be predicted on the basis of geometry alone. Since the amount of this stress alleviation is largely a function of the stress magnitude for any given material, it will be seen that the efficiency will depend to a great extent on the stress magnitude that is considered. Thus, for static failure in ductile materials, the amount of local stress alleviation will be quite high, and a joint may approach 100 percent efficiency, the most important determining factor being the amount of material removed in making the joint. But conversely, for fatigue failures that are caused by many repetitions of relatively low loads, the local stress at a stress raiser may be reduced very little by yielding, and the efficiencies may be nearly

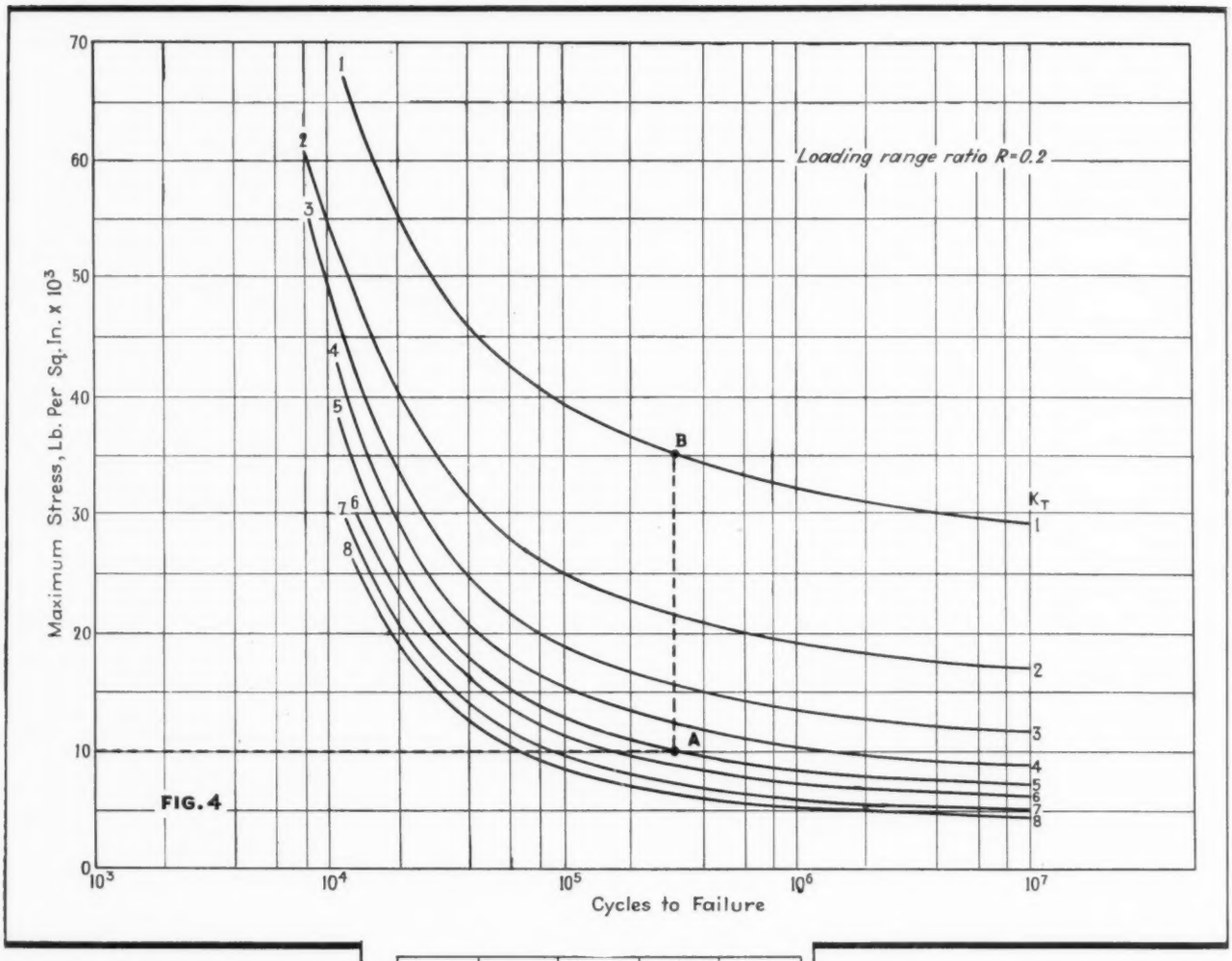


Fig. 4—S-N curves for 24ST Alclad sheet for different values of elastic stress concentration.

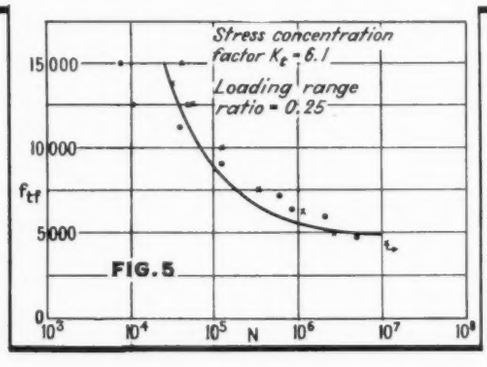


Fig. 5—Predicted curve and actual test points for 0.040 Alclad 24ST single row riveted lap joints with AN430 AD-5 Standard rivets at 1 in. pitch spacing.

as low as $1/K_t$, the amount of material removed being a comparatively small factor.

Effective Stress Concentration Factor in Fatigue. To show the variation in the effect of stress raisers on fatigue strength of ductile materials, an effective stress concentration factor in fatigue K_f or K_{fg}, has been defined (see V. Seliger, N.A.C.A. *Technical Note* No. 900) as the ratio of the fatigue strength of the basic material to the fatigue strength of a construction at a constant number of cycles to failure and a given loading range ratio R (ratio of minimum to maximum load in a loading cycle). The factor K_{fg} expressed on gross area, is therefore the reciprocal of the efficiency factor η, for any material or loading condition. Since this factor is defined in terms of fatigue strength, its evaluation depends on the availability of fatigue strength data for both the basic material and joint under required external loading conditions.

Efficiency of Typical Joints Under Repeated Loading. From the foregoing, it will be seen that for ductile materials the efficiency of joints under repeated loading depends on (1) the geometry of the joint, (2) the stress-strain properties of the structural material, and (3) the magnitude of the applied loading. In "An Empirical Approach to the Fatigue Strength Analysis of Structures," *Journal of Applied Mechanics*, Sept., 1946, page 201, the author and V. Seliger have presented an empirical method for evaluating the amount of alleviation of stress at a stress raiser, and hence for predicting the fatigue strength of various structural components on the basis of geometry (K_t), and the properties of a given material. This method will be used here in presenting examples of the variation in joint efficiency with joint geometry.

A number of S-N curves predicted by the referenced method for joints in Alclad 24ST material having values of K_t between 1 and 8, and a loading range ratio of 0.2 are shown in Fig. 4. Fig. 5 is taken from the referenced paper to demonstrate the correlation of this method of analysis with actual test points.

From Fig. 4, the values of η for R equal to 0.2 can be determined directly if the value of K_t for a given construction is known, since the curve for K_t equals 1 describes the fatigue strength of the basic material, while the other curves describe the fatigue strength of constructions having the stated values of K_t. For example, for an average maximum stress of 10,000 lb. per sq. in. on a joint having K_t equal

to 5.0, the fatigue life is 3 times 10^6 cycles, as indicated by point A in Fig. 4, while the basic material will withstand a stress of 35,000 lb. per sq. in. for the same number of cycles, as indicated by point B. Therefore, the net area efficiency of that joint at an average maximum stress of 10,000 lb. per sq. in. and R equal to 0.2 is

$$10{,}000/35{,}000 = 28.6 \text{ percent}$$

To convert this value to the gross area efficiency, this value must, of course, be multiplied by the ratio of net area to gross area.

By the same procedure, the curves of Fig. 6 have been plotted to show the variation in the gross area efficiency η, with K_t for various values of the varying stress in a loading cycle. The varying stress was used instead of the maximum stress to make the results more general, since the varying stress is so much more important a factor in determining fatigue strength than is the maximum stress that results plotted on the basis of varying stress can generally be assumed to apply over a fairly wide band of maximum stresses. It will be noted from these curves that the efficiency may vary over a very wide range while the stress magnitudes remain within practically usable values.

The effect of fastener geometry on joint efficiency is plotted in Fig. 7 for two different values of varying stress. These curves have been derived by combination of Fig. 3 with Fig. 6. It will be seen that the reduction in area, that is, rivet pitch, has little effect on joint efficiency for these loading conditions, until nearly half the area has been removed by the rivets. In contrast to joints in non-ductile material, the alleviation of stress in Alclad 24ST material by inelastic action has counteracted the higher elastic stress concentration factors applying at high value of rivet pitch. It will also be noted that the rate of change of efficiency with the ratio P_r/P_s is small, and hence that it will generally not be worthwhile from a fatigue strength standpoint to put in tapered doublers to reduce P_r/P_s to very low values. For example, even if the load is evenly divided between rivets in a rivet column, a change from a four rivet column to an eight rivet column would only lower P_r/P_s from 0.25 to 0.125, and probably would not significantly affect the efficiency.

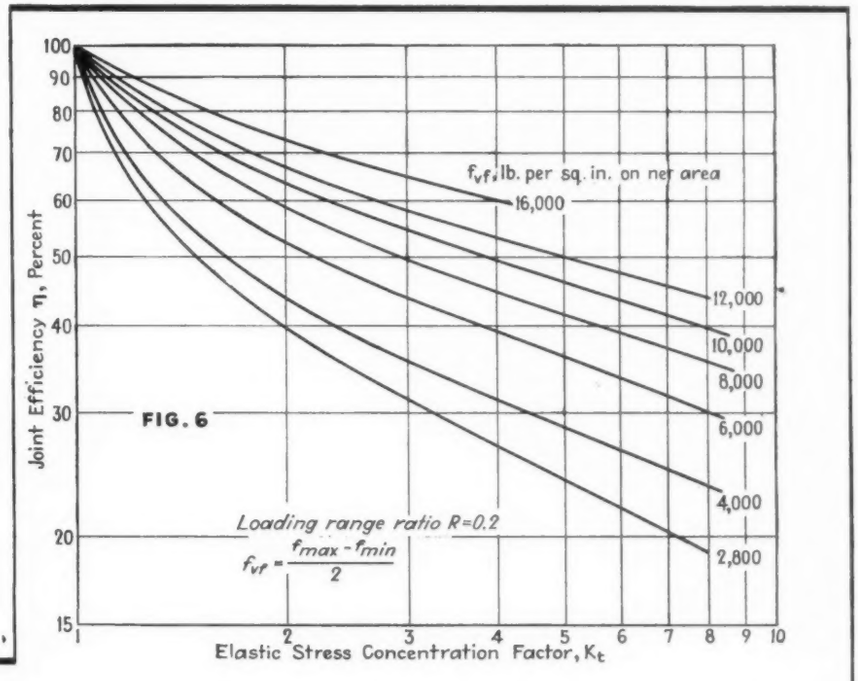


Fig. 6—Joint efficiency in fatigue as a function of the elastic stress concentration factor. Material is 24ST Alclad.

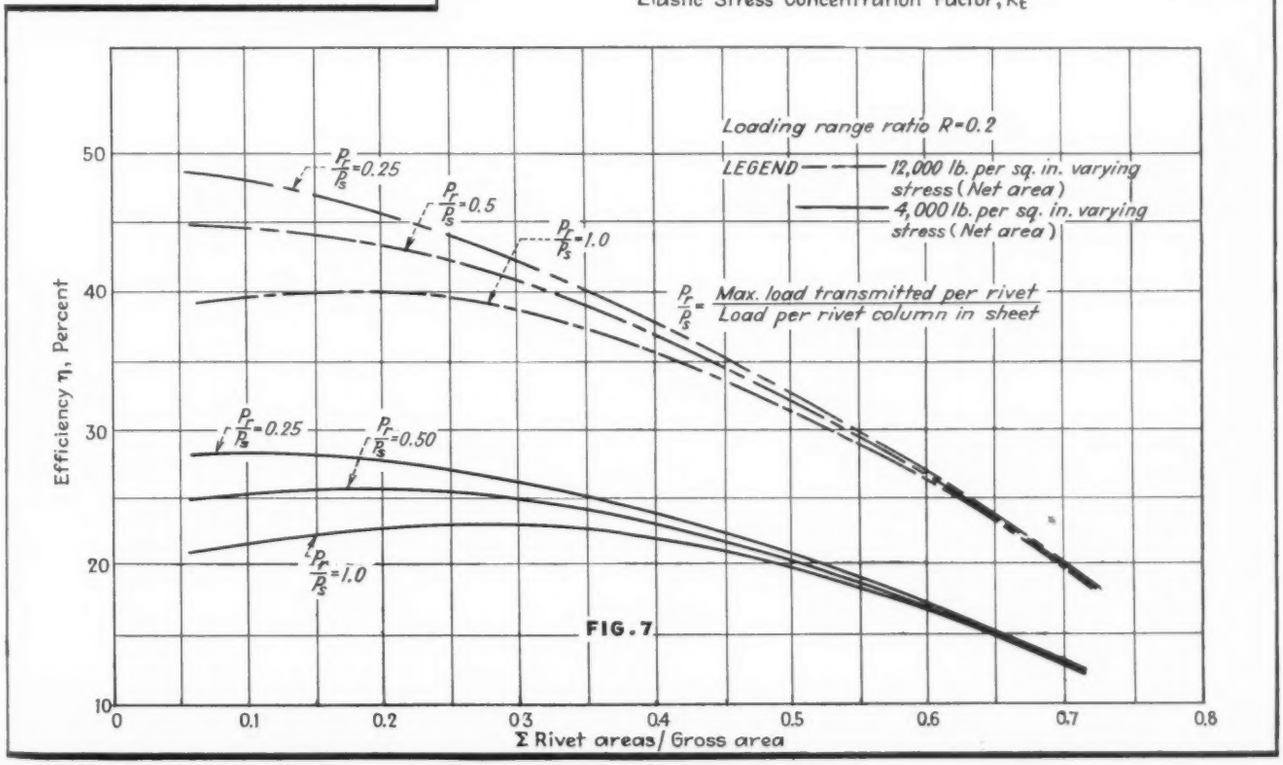
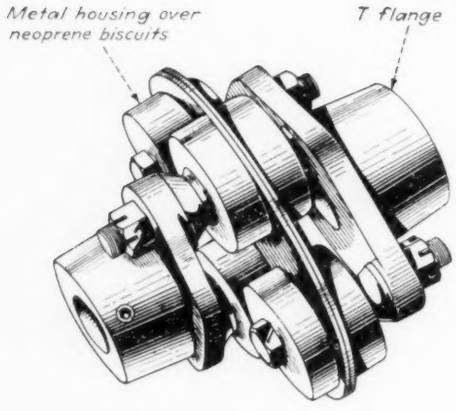


Fig. 7—Joint efficiency in fatigue and reduction in area by rivets. Round head rivets in Alclad 24ST.

TYPICAL METHODS OF COUPLING



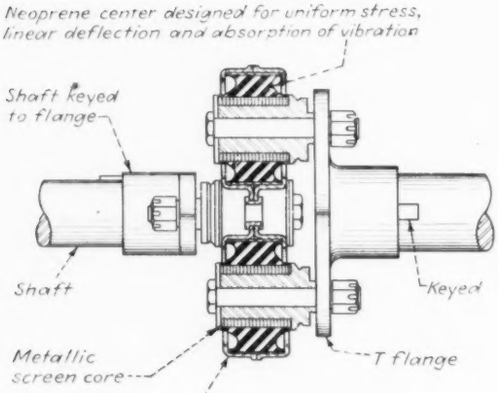

Neoprene center designed for uniform stress, linear deflection and absorption of vibration
Shaft keyed to flange
Shaft
Keyed
Metallic screen core
T flange
Outer fabric ring impregnated with neoprene, provides support for center section

FIG. 1 Morse Chain Co.

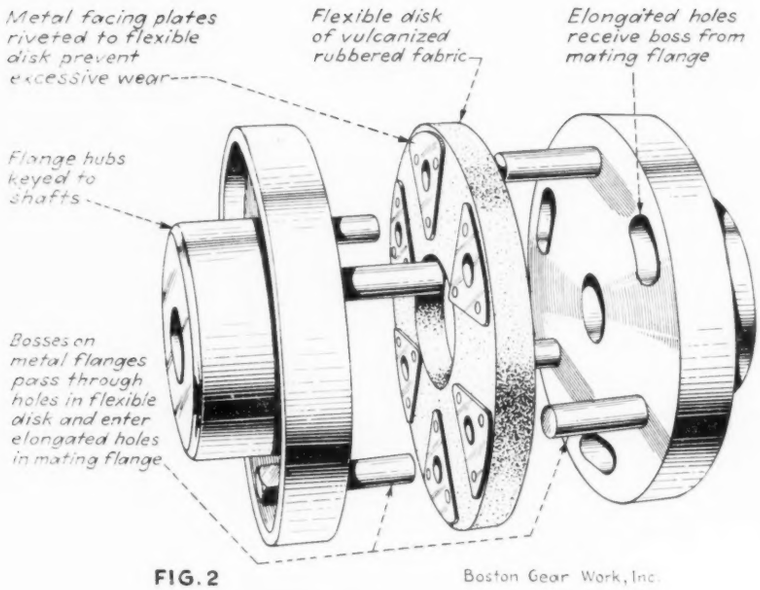

Metal facing plates riveted to flexible disk prevent excessive wear
Flexible disk of vulcanized rubbered fabric
Elongated holes receive boss from mating flange
Flange hubs keyed to shafts
Bosses on metal flanges pass through holes in flexible disk and enter elongated holes in mating flange

FIG. 2 Boston Gear Work, Inc.

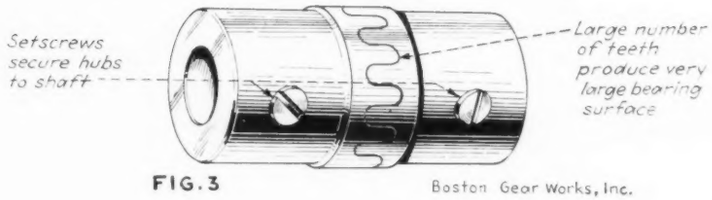


FIG. 3 Boston Gear Works, Inc.

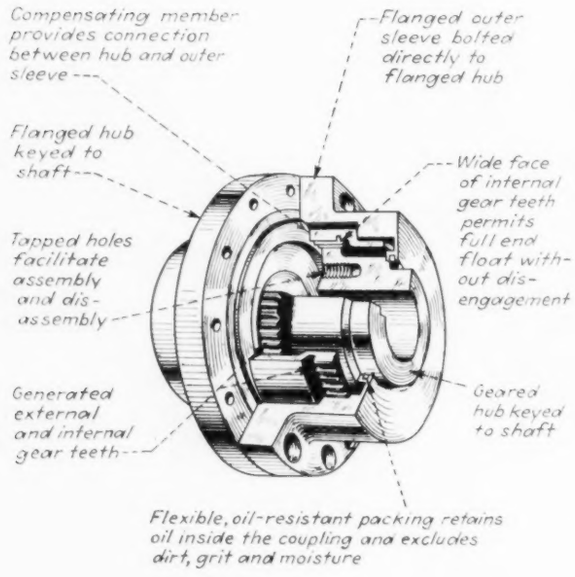

Compensating member provides connection between hub and outer sleeve
Flanged outer sleeve bolted directly to flanged hub
Flanged hub keyed to shaft
Wide face of internal gear teeth permits full end float without disengagement
Tapped holes facilitate assembly and disassembly
Generated external and internal gear teeth
Geared hub keyed to shaft
Flexible, oil-resistant packing retains oil inside the coupling and excludes dirt, grit and moisture

FIG. 4 Farrel-Birmingham Co., Inc.

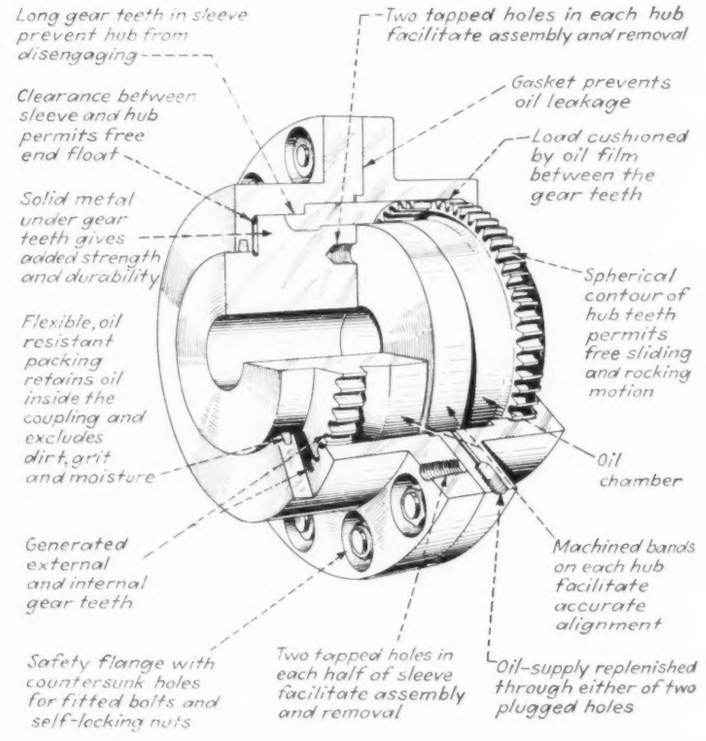

Long gear teeth in sleeve prevent hub from disengaging
Two tapped holes in each hub facilitate assembly and removal
Gasket prevents oil leakage
Clearance between sleeve and hub permits free end float
Load cushioned by oil film between the gear teeth
Solid metal under gear teeth gives added strength and durability
Spherical contour of hub teeth permits free sliding and rocking motion
Flexible, oil resistant packing retains oil inside the coupling and excludes dirt, grit and moisture
Oil chamber
Generated external and internal gear teeth
Machined bands on each hub facilitate accurate alignment
Safety flange with countersunk holes for fitted bolts and self-locking nuts
Two tapped holes in each half of sleeve facilitate assembly and removal
Oil-supply replenished through either of two plugged holes

FIG. 5 Farrel-Birmingham Co., Inc.

ROTATING SHAFTS—II

Shaft couplings that utilize internal and external gears, balls, pins, and non-metallic parts to transmit torque are shown herewith. Other types, incorporating chain belts, splines, bands, and rollers were presented in November Product Engineering.

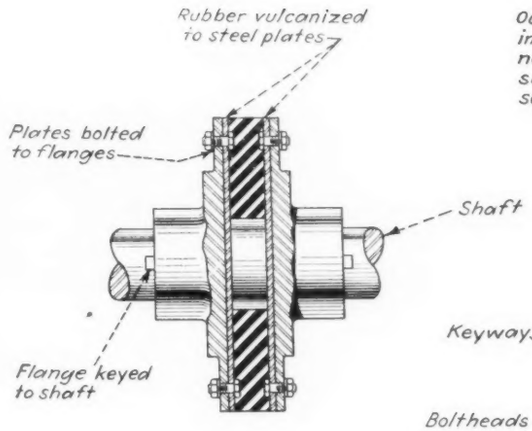


FIG. 6

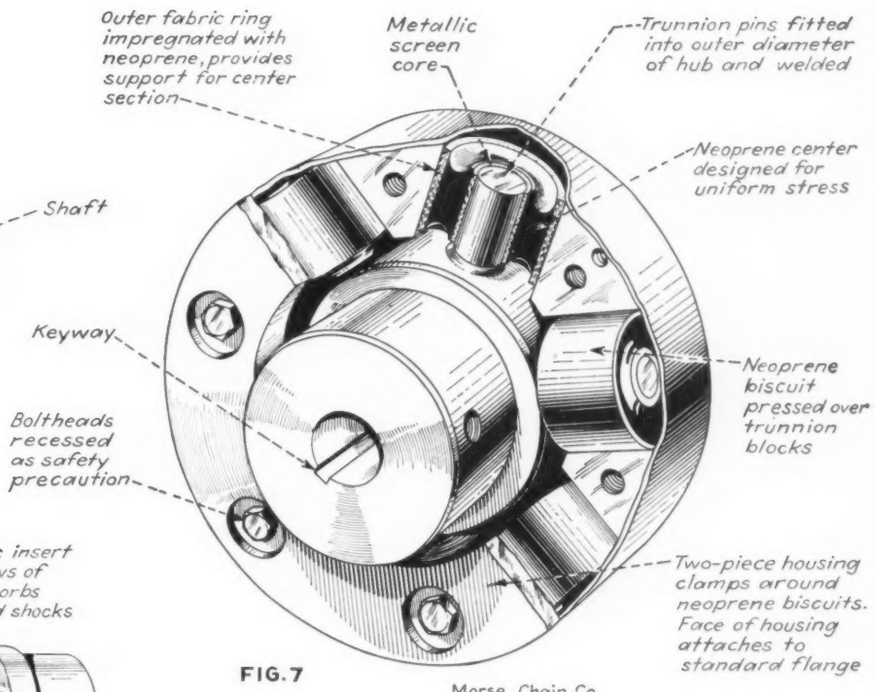

Outer fabric ring impregnated with neoprene, provides support for center section
Metallic screen core
Trunnion pins fitted into outer diameter of hub and welded
Neoprene center designed for uniform stress
Keyway
Neoprene biscuit pressed over trunnion blocks
Boltheads recessed as safety precaution
Two-piece housing clamps around neoprene biscuits. Face of housing attaches to standard flange

FIG. 7 Morse Chain Co.

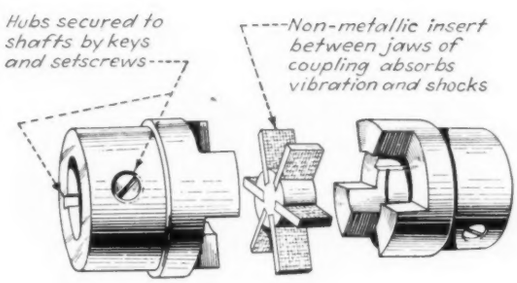

Hubs secured to shafts by keys and setscrews
Non-metallic insert between jaws of coupling absorbs vibration and shocks

FIG. 8 Boston Gear Works, Inc.

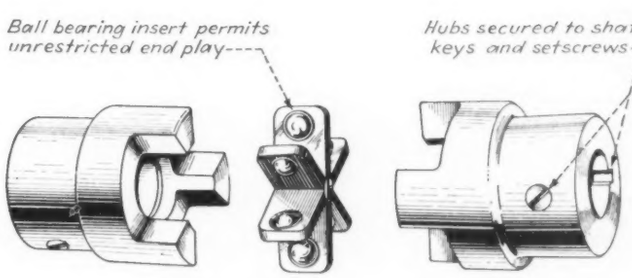


FIG. 9 Boston Gear Works, Inc.

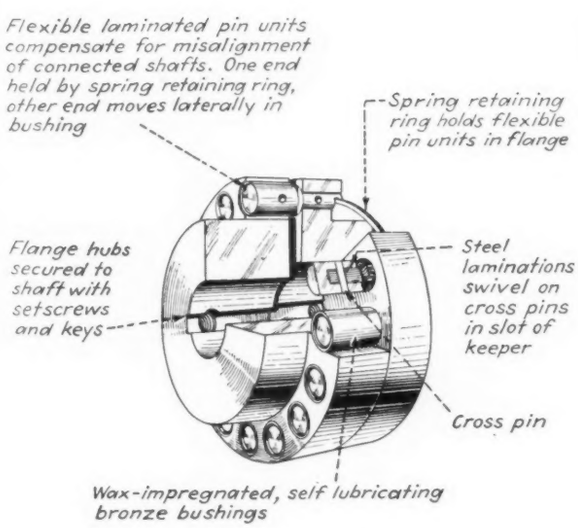

Flexible laminated pin units compensate for misalignment of connected shafts. One end held by spring retaining ring, other end moves laterally in bushing
Spring retaining ring holds flexible pin units in flange
Flange hubs secured to shaft with setscrews and keys
Steel laminations swivel on cross pins in slot of keeper
Cross pin
Wax-impregnated, self lubricating bronze bushings

FIG. 10 John Waldron Corp.

No lubrication is required on this coupling

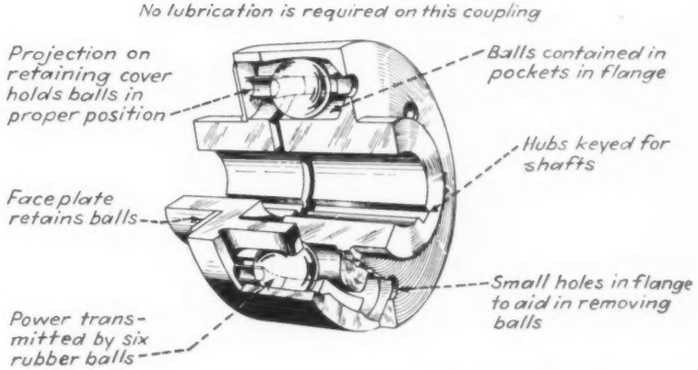

Projection on retaining cover holds balls in proper position
Balls contained in pockets in Flange
Hubs keyed for shafts
Face plate retains balls
Small holes in flange to aid in removing balls
Power transmitted by six rubber balls

FIG. 11 Crocker-Wheeler Div., Joshua Hendy Iron Works

Output of Induction Motor Depends on Total Active Material

P. H. TRICKEY
Chief Engineer, Diehl Manufacturing Company

Simplified method for simply and quickly calculating the size of a fractional or integral horsepower induction motor for different frequencies and types of service.

THE OUTPUT of an induction motor depends on the volume of useful material in the whole motor. This volume is usually expressed as the $(OD)^2W$, where OD is the outside diameter of the stator laminations and W is the width or "stack" of the stator core, as shown in Fig. 1. This differs from the practice on d.c. motors where only the armature is considered.

The value of $(OD)^2W$ is not directly proportional to output, but varies with the horsepower. For instance, a 1/4 hp. motor requires more material per watt output than a 10 hp. motor. The size is also affected by many other considerations. For example, a single phase motor is larger than a polyphase motor, and a general purpose, high efficiency motor is larger than a washing machine motor where efficiency is of secondary importance.

Relative costs of material and labor, new materials, improvement in ventilation methods, new methods of manufacture all affect the final size of a motor. Special emphasis by a large group of users or product designers on some one factor such as efficiency, power factor or overload torque may influence the relation of the $(OD)^2W$ value to output.

The effect of these different factors are divided into two groups. Fig. 2 shows the variation in size in terms of horsepower and number of poles. The frequency constant, C_f, and an illustrative list of "type constants", C_T, for various kinds of motors and applications are listed. Using Fig. 2, the following example shows the five steps for determining the size of a 1/3 hp., 4 pole, 1,725 r.p.m., 3 phase, 60 cycle, open general purpose polyphase motor:

1. From the table of Type Constants, $C_T = 1.00$
2. From curve in Fig. 2(A) for 4 pole motor, Output Constant, $C_1 = 0.34$
3. From table of Frequency Constants, $C_f = 1.00$
4. Substituting in formula

$$(OD)^2W = C_1 \frac{\text{hp.}}{\text{r.p.m.}} \quad C_f\ C_T\ 10^6$$

$$= 0.34 \times \frac{0.333}{1{,}725} \times 1.00 \times 1.00 \times 10^6$$

$$= 65.8 \text{ cu. in. of volume}$$

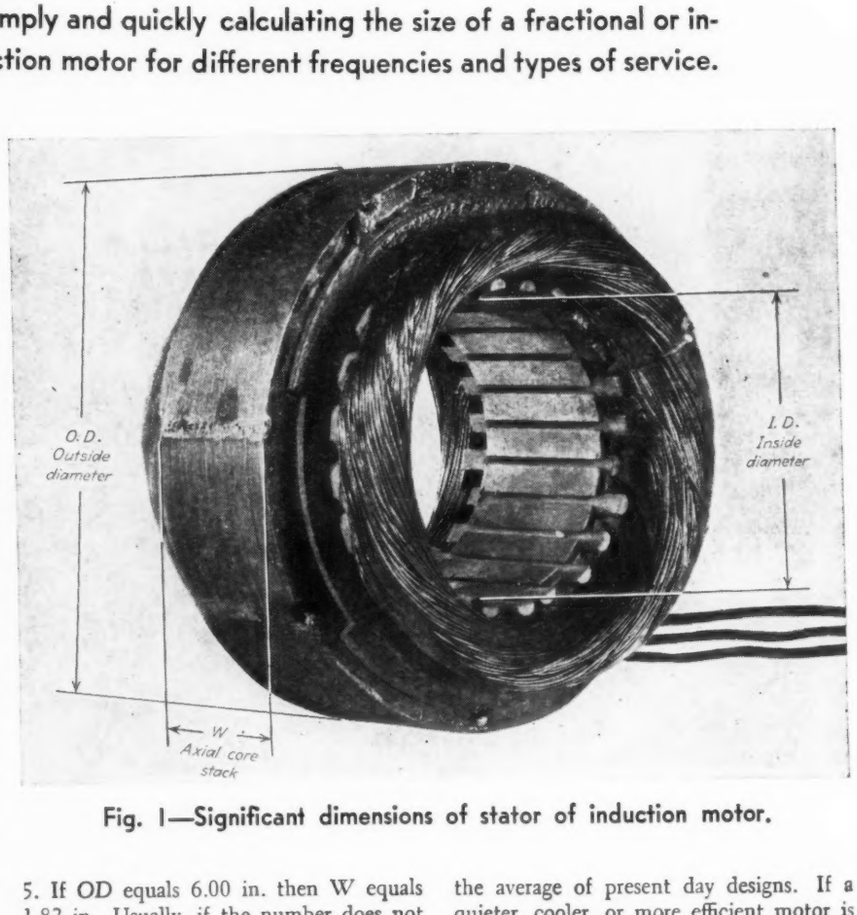


Fig. 1—Significant dimensions of stator of induction motor.

5. If OD equals 6.00 in. then W equals 1.82 in. Usually, if the number does not come out even the nearest even fraction is used, such as 1¾ inch.

If a type constant is not known for a new and different design for a range of motors, it may be necessary to determine the $(OD)^2W$ of one motor of the new group of motors either from the size of an existing motor or by a thorough trial and error design.

After the $(OD)^2W$ of one motor is known, it is a simple matter to solve the equation of Fig. 2 for the type constant. This then fixes a consistent size for each motor in the group.

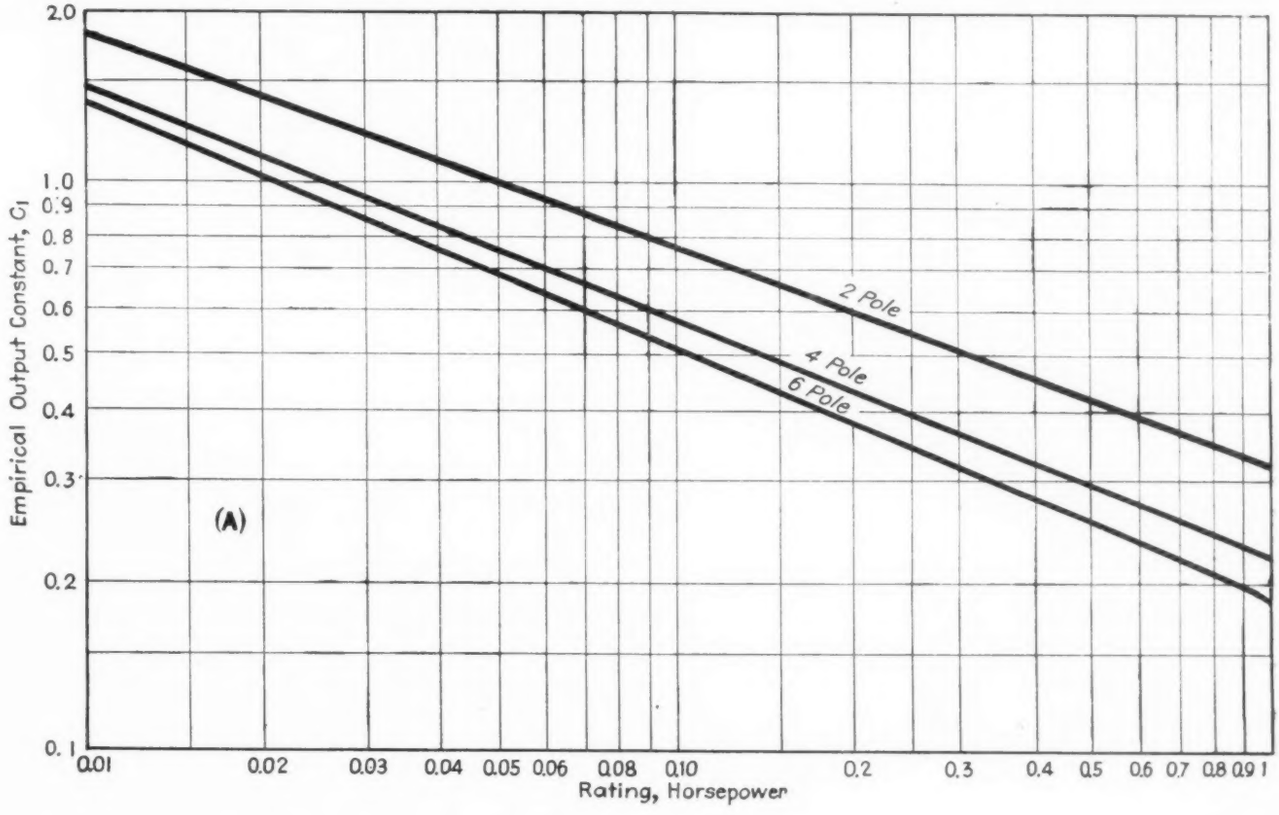
The value of the type constant, C_T, will be slightly different with each manufacturer because of different manufacturing variations, such as the most economical winding tightness or "fill factor."

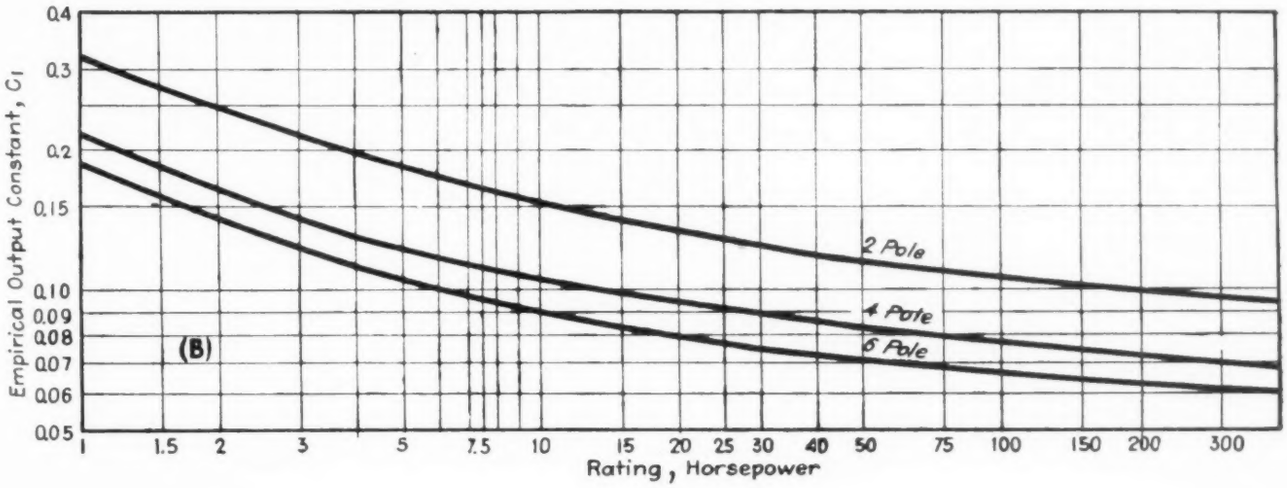
The values of C_T shown in Fig. 2 give motors with performance about equal to the average of present day designs. If a quieter, cooler, or more efficient motor is wanted C_T should be increased slightly. If a noisier, more closely rated, or less efficient motor will do, the C_T can be made somewhat smaller.

The proportions of OD and W can vary widely without the performance being greatly affected. Usually the OD is influenced by the required shaft height or by the mounting dimensions of a machine.

Common proportions of stator inside diameter to outside diameter are shown in Fig. 3; and Fig. 4 is often used for the air gap density of the first trial winding.

Totally inclosed motors are usually limited by the amount of heat loss the frame will dissipate, and the type constant can only be used as a guide to the minimum size from a performance standpoint. A dissipating area of 1.67 sq. in. per watt loss is usually necessary for a 55 deg. rise motor.





Where:
OD = outside diameter of stator laminations, in.
W = width of stator core, in.
C_1 = output constant, from curve
hp. = horsepower
r.p.m. = revolutions per minute
C_f = frequency constant, from table
C_T = motor-type constant, from table

the cubic inches of useful material is:

$$(OD)^2W = C_1 \left(\frac{\text{hp.}}{\text{r.p.m.}}\right) C_f\, C_T\, 10^6$$

Frequency, f cycles per sec.	Frequency Constant C_f
60	1.00
50	0.96
25	0.87

Type of Motor	Type Constant C_T
Polyphase General Purpose	1.00
Split Phase	
General purpose	1.42
Special service, mach. wound	1.25
Special service, hand wound	1.09
Capacitor Start	
General purpose	1.42
Special service	1.25
Repulsion Start	
General purpose	1.85
Special service	1.42

Fig. 2—Relation of output constant to hp. for induction motors. (A) Fractional hp. sizes. (B) Integral hp. sizes.

(*Continued on next page*)

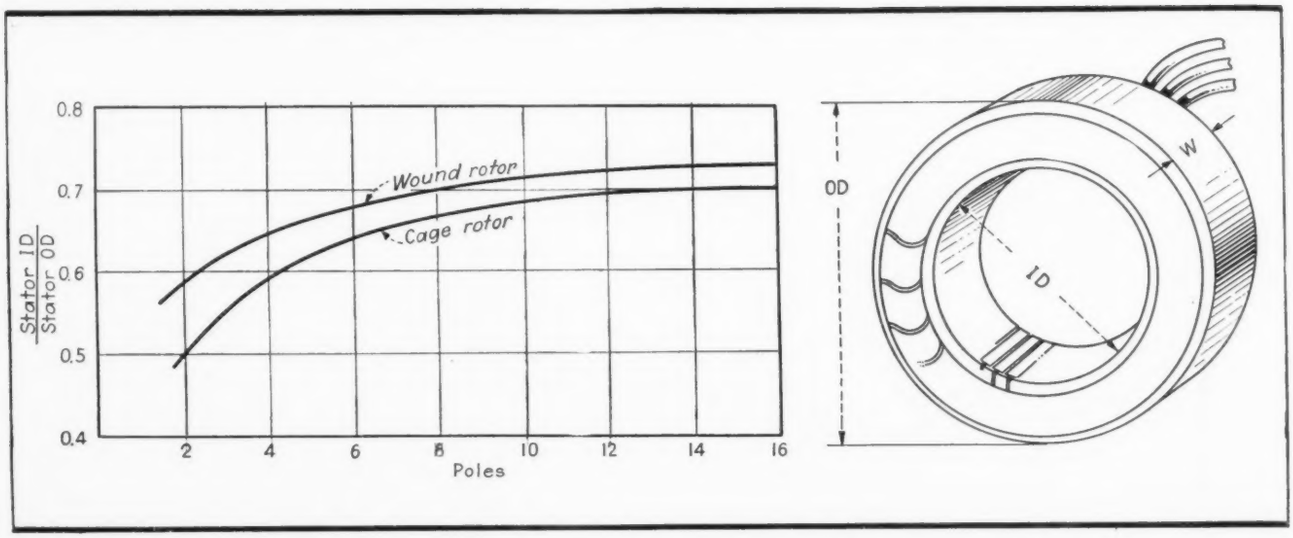
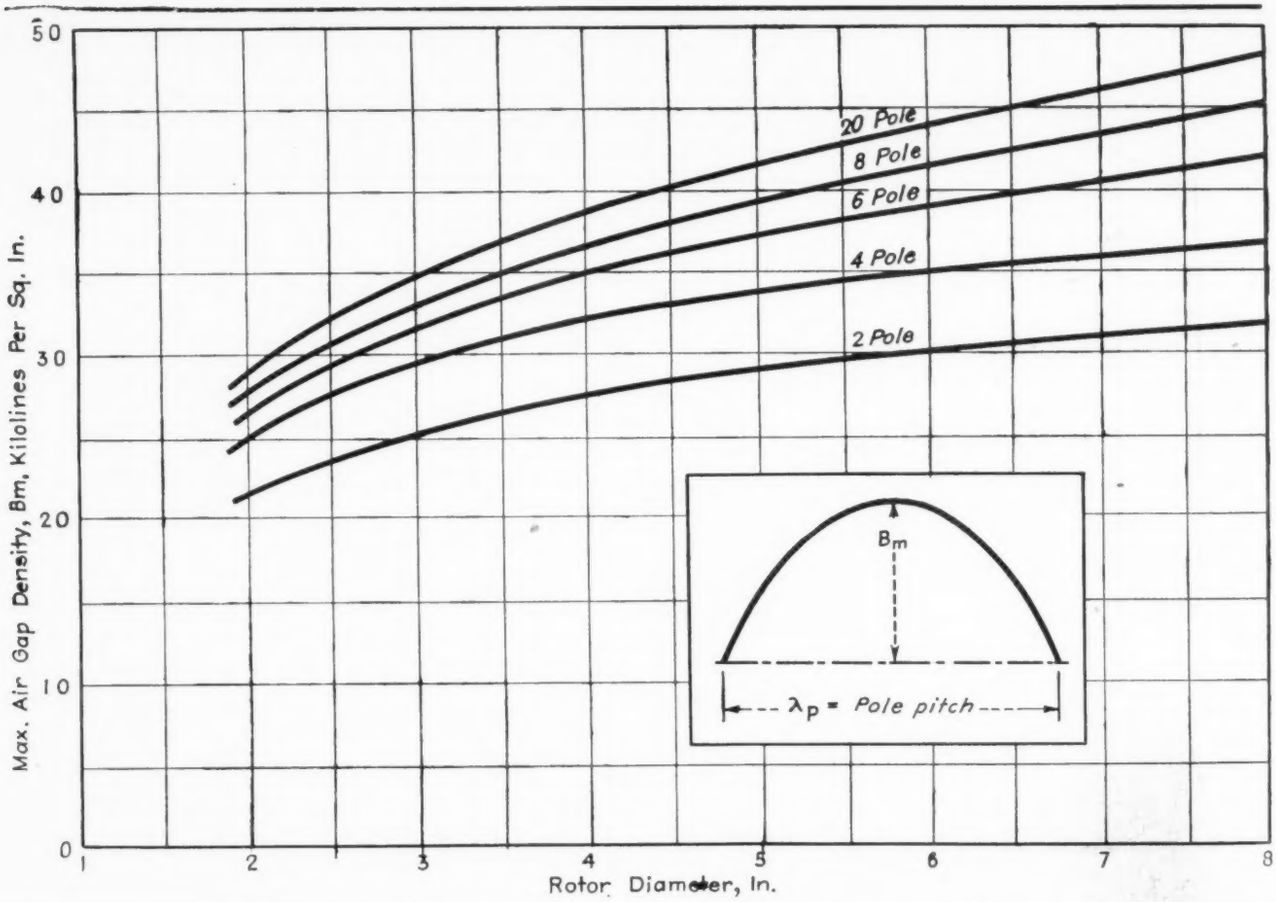


Fig. 3—Common proportions of inside diameter to outside diameter of stator.



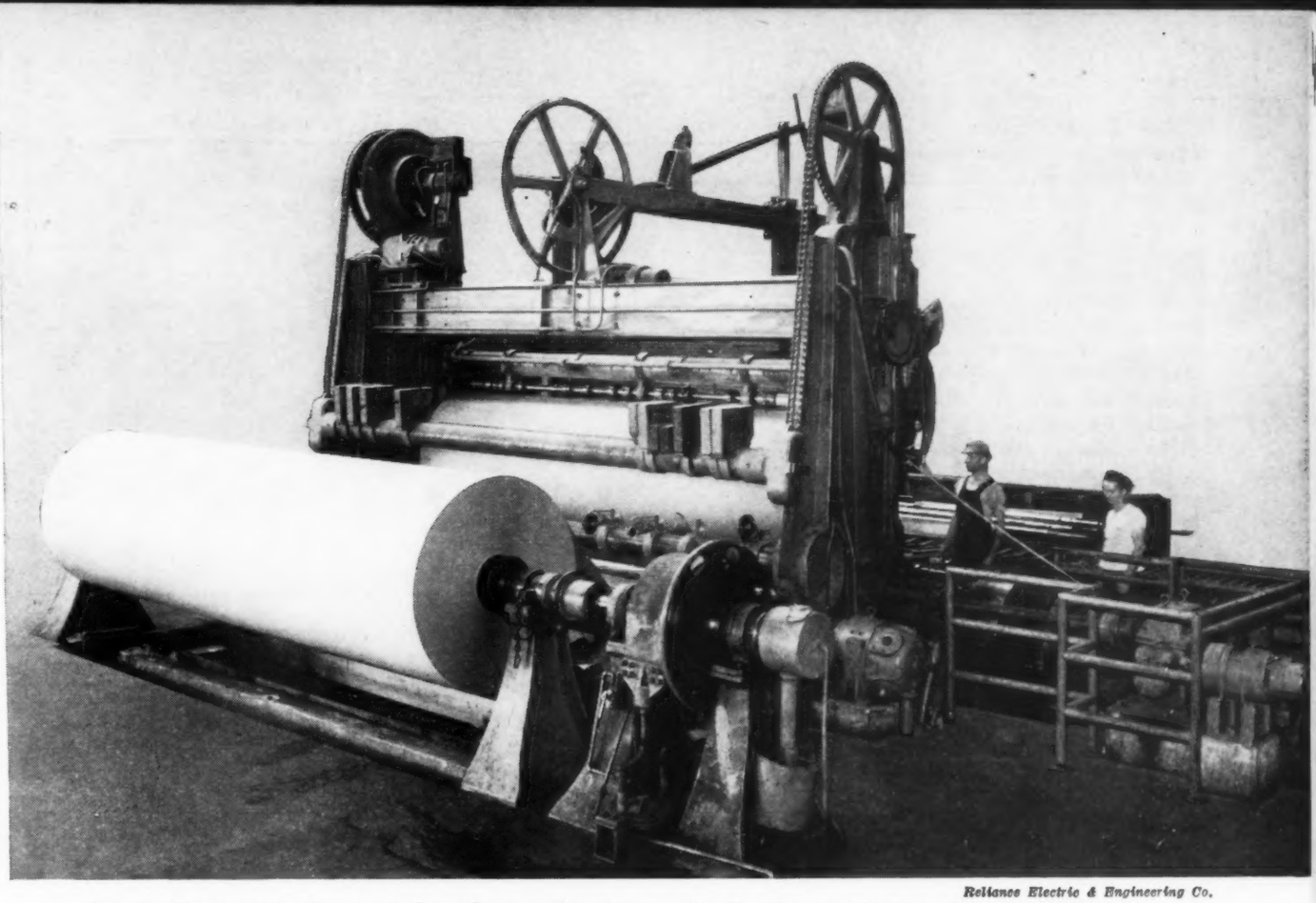
Where:
E_{ph} = volts per phase
CK_w = effective series conductors per phase
f = frequency, cycles per sec.
W = axial core stack
λ_p = pole pitch

Then the maximum air gap density, B_m, in kilolines per sq. in. is:

$$B_m = \frac{45\,E_{ph}\,10^6}{CK_w\,f}\,\frac{1}{\lambda_p W}\,\frac{\pi}{2}$$

For the following conditions, multiply B_m by:
1.00 for 60 cycles 1.10 for single phase general purpose
1.05 for 50 cycles 1.32 for single phase special purpose
1.20 for 25 cycles 0.9 for fan duty

Fig. 4—C. K. Hooper's curve of air gap density of polyphase motors based on four pole laminations for all poles.



Reliance Electric & Engineering Co.

Fig. 1—Constant tension control produces uniformly-wound rolls of material that will not telescope.

Constant Tension Control Systems For Surface and Mandrel Winding

J. E. JONES
Supervising Engineer, Cutler-Hammer, Inc.

When winding material such as paper, cellophane, fabric, and metallic strip automatic tension control prevents breakage and produces uniformly-wound rolls that will not telescope. Surface and mandrel winding methods, basic circuits for rider roll rheostat control, and automatic constant tension system with WR^2 compensation are explained and discussed.

WHEN MATERIAL in long sheets or strips is being manufactured or processed, it is usually wound in coils or rolls so it is easily transferred to other process machines, stored, or marketed. In winding the coils, such as shown in Fig. 1., controlled tension produces an evenly-wound roll and prevents damage or breakage of the material. The material to be coiled may range from fragile tissue paper to steel strip of substantial thickness.

Delicate control is required on most grades of paper, cellophane, and similar materials having relatively low tensile strength. If this material is wound too loose on the outside, the roll may telescope. If wound loose in the center and tight on the outside, the roll may be damaged by certain atmospheric conditions. When winding metal strip there is little danger of breaking the strip, but reasonably close tension control insures a coil that will withstand handling without telescoping. In general, if the tension cannot be held absolutely constant, it should be greatest at the core and decrease very slightly as the roll diameter increases.

In paper mills, the terms "winder" and "rewinder" are used. The winder, or reel, is usually at the finish end of a paper making machine and winds up the paper as it comes from the machine. In most of the paper making processes, the rolls from the winder are then put through some form of finishing and slitting operation and then are carefully wound up

again on a rewinder in satisfactory form for market purposes. The rewinder perform the final winding operation.

Surface Winding

Surface winding is used principally for winding paper rolls. The core on which the paper is wound is driven by friction from a smooth steel roll. The peripheral speed of the roll is the same as the linear speed of the paper. The paper roll is held in firm contact with the surface winder either by its own weight or by means of a pressure device. The pressure device can be spring or weight loaded or can use torque motors to obtain the necessary pressure between the paper roll and the winding drum.

The most common surface rewinder in paper mills is the cradle winder. This consists of two winding drums mounted close together so that the roll of paper is supported, or cradled, between them as shown in Fig. 2. Early designs were belt driven but more recent designs use a spearate driving motor on each drum. These motors are supplied with power from an adjustable-voltage generator.

Individual control of each drum motor is by vernier adjustment of its shunt field. The roll can be wound tight or loose depending upon how the driving effort is distributed between the two motors. Each motor is usually large enough to carry the load by itself since at times one motor may be idling or may be holding back slightly.

Cradle winders are sometimes built with four or more drums. This permits unwinding a large roll through a slitter and rewinding two or more rolls with independently controlled tension.

Winders that roll up paper at the end of the paper making machine must be driven at the same speed as the paper and, therefore, are interlocked mechanically or electrically with the paper machine.

Mandrel Winding

Mandrel winders are used for winding rolls or coils of sheet material, usually paper, cloth or metal. The core or mandrel is driven by a motor as shown in Fig. 3. Because the length of turns varies with the diameter of the roll, the speed of the winder motor must vary directly with the diameter of the roll if the linear speed of the strip is constant. Basic relations pertaining to mandrel winding are:

P = pull in sheet, lb.

S_1 = linear speed, ft. per min.

$Hp. = \frac{P\,S_1}{33{,}000}$ and is constant

R = radius of coil at any instant, ft.

T_1 = torque at mandrel shaft

$T_1 = P\,R$, and varies directly with the coil diameter

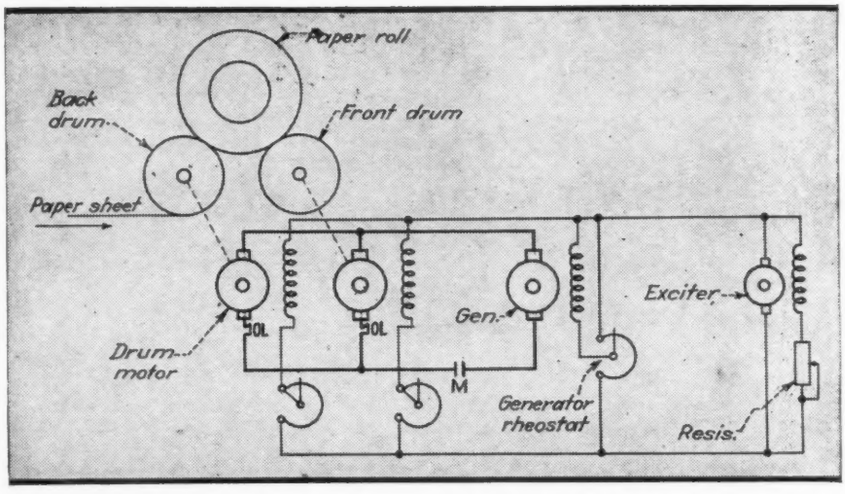


Fig. 2—Cradle type surface winder with two drums that support paper roll.

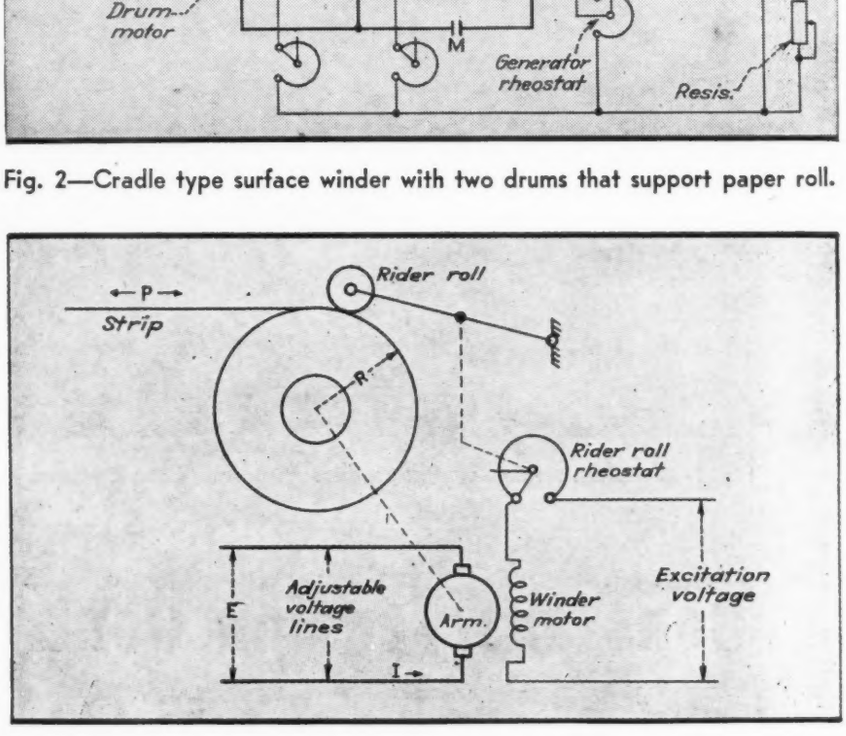


Fig. 3—Mandrel winder with rider roll rheostat for constant tension control.

S_2 = mandrel speed $= \frac{S_1}{2\,\pi\,R}$ r.p.m., and varies inversely with the coil diameter

Since the drive is constant horsepower, the voltage E and the current I of the motor will be constant. E is proportional to the linear speed S_1. I is proportional to the tension P.

Motor torque $= K_1\,T_1 = K_2\,\phi\,I$

Therefore, the motor flux ϕ must vary directly with roll diameter, since I is constant.

Motor speed $= K_1\,S_2 = K_3\,E/\phi$

Here again, the motor flux must vary directly with roll diameter since E is constant.

Therefore, the motor torque and speed can be kept in the proper relation for constant tension by simply changing the motor field flux as the diameter of the roll changes. If the armature current I is to be a direct indication of tension, the following are requirements:

1. The linear speed changes of the sheet must be made by changing the applied voltage E.

2. Motor speed variation with change in roll diameter must be accomplished by field flux variation. This is usually done automatically. The important point is that for each increment of roll diameter there is a value of motor field flux that is independent of the speed or tension settings.

3. Tension adjustments must be made by adjusting the motor armature current, I. Thereafter, it is usually automatically maintained constant at the desired value.

The ratio of maximum roll diameter to mandrel diameter is limited to the speed range of the motor by shunt field control. The motor field range should be somewhat more than the ratio of buildup of the roll to allow some plus and minus correction at each end of the range. For instance, a 3½ or 4 to 1 motor would be used for a buildup ratio of 3 to 1 from bare mandrel to full roll diameter.

Rider-Roll Rheostat Control. A mandrel winder with a rider-roll rheostat is the

simplest system for holding constant tension, as shown in Fig. 3. The motor armature is connected to the d.c. line driving the preceding machine section. The motor field rheostat is sprocket or gear driven from a rider-roll mechanism. The rider roll rests on the surface of the coil in such a way that it follows the buildup of the coil and provides the correct motor field strength as the coil diameter changes.

This system has been used in the past, particularly on strip steel, but is rarely used now. It has been largely replaced with schemes that automatically control tension by the use of automatic regulators.

AUTOMATIC TENSION CONTROL. Simplified connections of an automatic constant-tension circuit for a mandrel winder are shown in Fig. 4. The d. c. drive motor has a constant horse power rating consistent with the speed and tension requirements. Its speed range by shunt field control is slightly greater than the ratio of maximum to minimum coil diameter.

The winder motor armature is connected to an adjustable-voltage d.c. power source. The power supply can be from a separate generator or from a generator that supplies other machine portions in the process. The linear speed of the sheet is varied by changing the d. c. voltage applied to the armature. The motor is usually started at low generator voltage and is accelerated to the desired linear speed by the generator field rheostat, which is often motor-operated.

A booster generator is sometimes used in the winder motor armature circuit. This low voltage generator can be used to provide stalled tension at standstill. This condition is desirable when starting a new roll. Usually, the end of the strip is inched up to the winder and made fast to the core. The stalled tension button is then pressed; it releases the winder brake and excites the booster field to produce enough armature current in the winder motor to hold the strip taut. This arrangement also holds the strip taut when a stop is made in the middle of a roll for inspection, or other reasons.

Automatic tension regulation can be provided by several devices, the most common being solenoid-operated regulators, electronic regulators, and rotating regulators. Electronic regulators are generally applied on drives using small motors, where the electronic control is less expensive than magnetically-operated regulators. Both the armature and field circuits can be supplied by electronic rectifiers and this is sometimes done when the winder is a self-contained unit.

However, if the winder works with some form of mill or with an unwinding stand, there is some advantage in favor of using rotating units for the armature circuits. This helps to keep the motors in the proper speed relation to each other, and permits certain motors, such as drives for pinch rolls or uncoilers, to regenerate back into the lines to produce the necessary hold back. Rotating regulators are coming into more general use and are particularly well adapted to large machines using large motors.

All automatic regulators used to produce constant tension by holding the armature current constant are in reality voltage regulators. A small voltage drop in the winder motor armature circuit is used to actuate the regulator, and the regulator acts to keep this voltage constant.

Most regulators require 4 or 5 volts at rated motor current. This voltage drop is produced across a small resistor in the armature circuit as shown in Fig. 4, or the voltage drop across an interpole field winding is sometimes used. When a reduced value of tension is wanted, the regulator is caused to balance at a lower drop across the resistor, and it then maintains this lower value constant.

The circuit in Fig. 4 shows a solenoid-operated regulator with a rocking contact because it is easy to show the action schematically. The following step by step description of the regulator action applies equally well to other types of regulators. The rocking contact rheostat is operated from a solenoid through an almost frictionless mechanism. The solenoid has three windings. One, the motive coil, is connected across the *IR* voltage drop resistor in the winder motor armature circuit. It is the coil that detects any deviation from the desired armature current and acts to restore it to a preset value. The second, the adjusting coil, is used to adjust the tension by means of a rheostat connected in series with it. The solenoid plunger balances in regulating position at a definite ampere-turn value. This is made up of the sum of the ampere-turns of the motive and adjusting coils. Therefore, the ampere-turns of the motive coil, and with it the tension, can be changed by varying the adjusting coil. When greater tension is desired, the adjusting coil is weakened, which requires that the armature current increase to increase the ampere-turns of the motive coil.

Referring to Fig. 4, assume stable operation at the desired tension. Under this operating condition for the system, material is being wound on the roll at constant linear speed and the roll is steadily getting larger in diameter. As the roll diameter tends to increase, the motor momentarily tries to drive the roll faster than required, and in so doing tends to take a slightly greater armature current. This increases the *IR* voltage drop slightly causing the regulator plunger to rise a small amount, and the movement causes the rocking rheostat to short out more resistance and thus strengthen the motor field. This greater field flux tends to slow down the motor and to increase its torque in keeping with the increase in roll diameter. Thus, by holding constant armature current, the regulator varies the motor flux and keeps the motor speed and torque in a proper

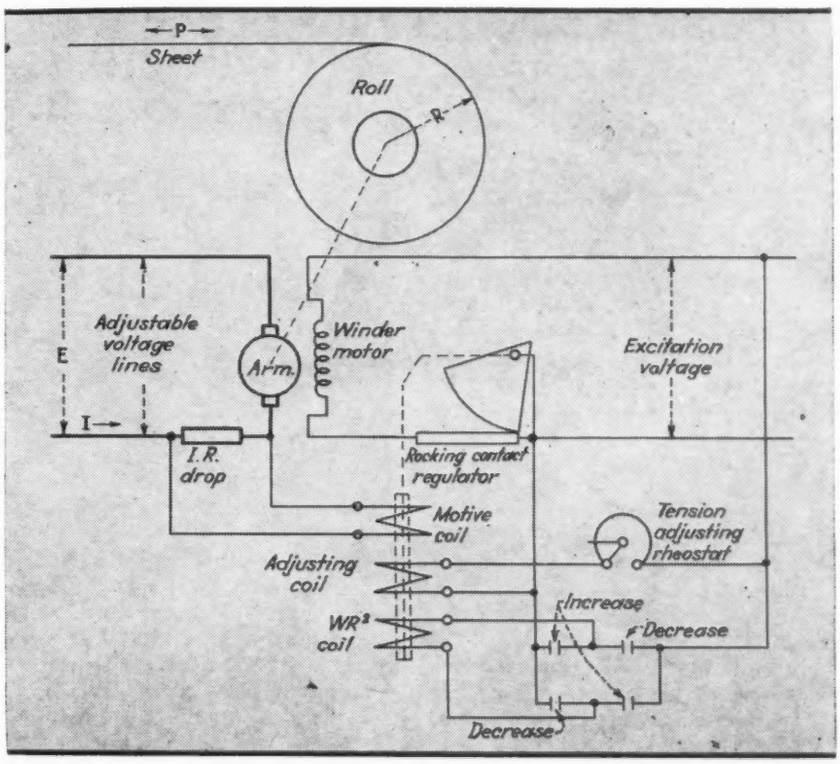


Fig. 4—Mandrel winder with automatic tension control uses multiple coils.

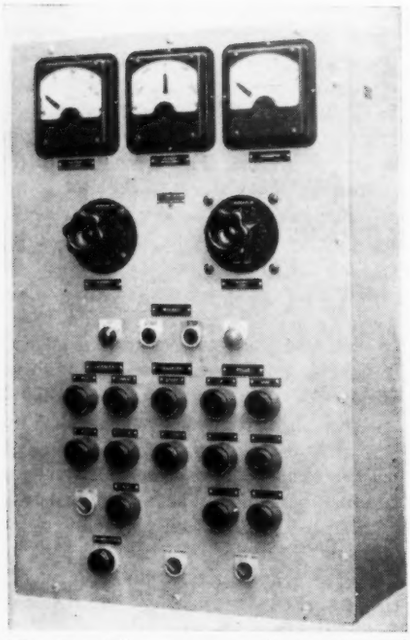


Fig. 5—All necessary electronic and adjustable-voltage controls and meters for controlling the operation of a rubber calender are contained in one compact operator's station.

balance with the roll diameter at all times, thereby producing constant tension.

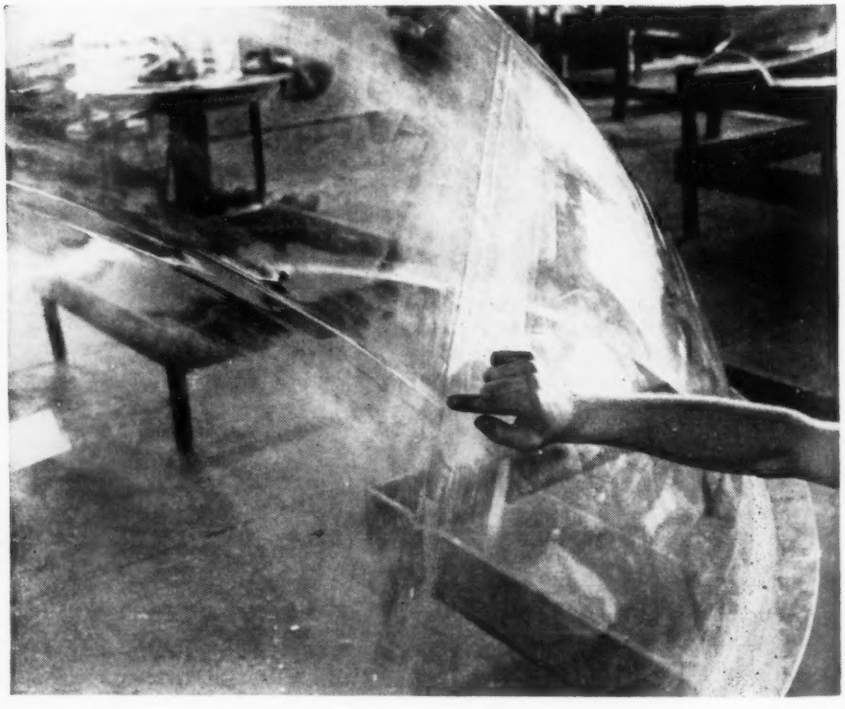
WR^2 Compensation. The WR^2 winding of the regulator is used to modify the ampere-turns of the motive coil during acceleration and deceleration. Thus it maintains the desired tension when the linear speed is being changed. During acceleration of the winder, the regulator should allow more than the preset value of armature current to flow since greater torque is needed then to hold the tension and to overcome the inertia of the rotating parts. At this time, the WR^2 coil bucks the other coils, and thus permits a larger armature current to flow. During deceleration, the WR^2 coil is reversed so that it is cumulative with the other coils and balances the regulator at a smaller armature current than the preset value, or perhaps a reverse current. The action of this rocking-contact type tension regulator applies equally well to other solenoid-operated regulators. In addition, the general principles discussed are employed when electronic and rotating regulators are used instead of the systems described.

To control constant tension regulating systems, the pushbuttons, tension selectors, speed selectors and indicating instruments, are usually mounted in a control station, such as Fig. 5, for easy and convenient use by the operator.

Sometimes a process may have an unwinding reel and a wind-up reel, with some other process in the span of material between these reels. Both the unwind and the wind up sections can have automatic tension control. Such tension systems will work satisfactorily if the work being done on the material in the intermediate sections is sufficient to isolate completely the two tension systems. If the two tension systems are not isolated, they will work against each other. On processes where the two systems cannot be completely isolated, it is desirable to change the pay-off reel to a constant linear speed control and have constant tension control on only the wind-up reel.

There are many variations of constant tension regulators, and for best results each new machine and process should be analyzed individually. As peacetime industry continues to use automatic machines to reduce the unit cost of products it is likely that increasing use will be made of precise automatic tension control.

Large Transparent Plastic "Bubble"



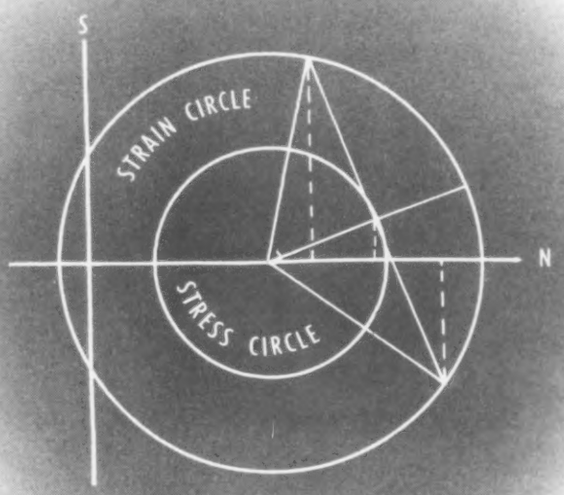
World's largest transparent "bubble", made of Plexiglas, has recently been completed by the E. L. Cournand Company, of New York City. Measuring almost eleven feet in diameter and four and one-half feet deep, the dome was designed by Edward H. Burdick Associates for an outdoor advertising display erected for the Ford Motor Company, of Detroit, Mich. The dome which is not quite as deep as a hemisphere; was made by a forming method which consists of drawing a heated Plexiglas sheet into a vacuum pot and allowing the sheet to cool.

The major problem was obtaining a large enough sheet. Rohm & Haas Company of Philadelphia, manufacturer of Plexiglas, supply some very large sheets, but a sheet 132 in. square was well beyond present production limitations. It was therefore necessary to join several sheets with a bond strong enough to withstand the vacuum used to form the dome and, more important, the stretching involved in the forming operation. In addition, the joints were to be as inconspicuous as possible.

The final, successful method evolved consisted of routing a concave V-groove in both edges of the Plexiglas sheets to be joined, soaking a cast acrylic rod in monomeric methacrylate cement, and placing the softened rod between the grooved edges. When the sheets were brought together under pressure, the rods served to keep the edges in proper alignment. Ultraviolet and infra-red lamps were placed above and below the joints to convert the monomer cement to solid plastic.

As important as the joints themselves, however, was the position of these joints on the final, assembled sheet. One reason for the failure of some of the earlier joints was that they were in the center of the sheet and therefore subjected to greatest stretching. The layout finally used called for two pieces in the center, two more in the middle of both sides forming wings, and smaller pieces completing the corners.

SYMPOSIUM
EXPERIMENTAL STRESS ANALYSIS

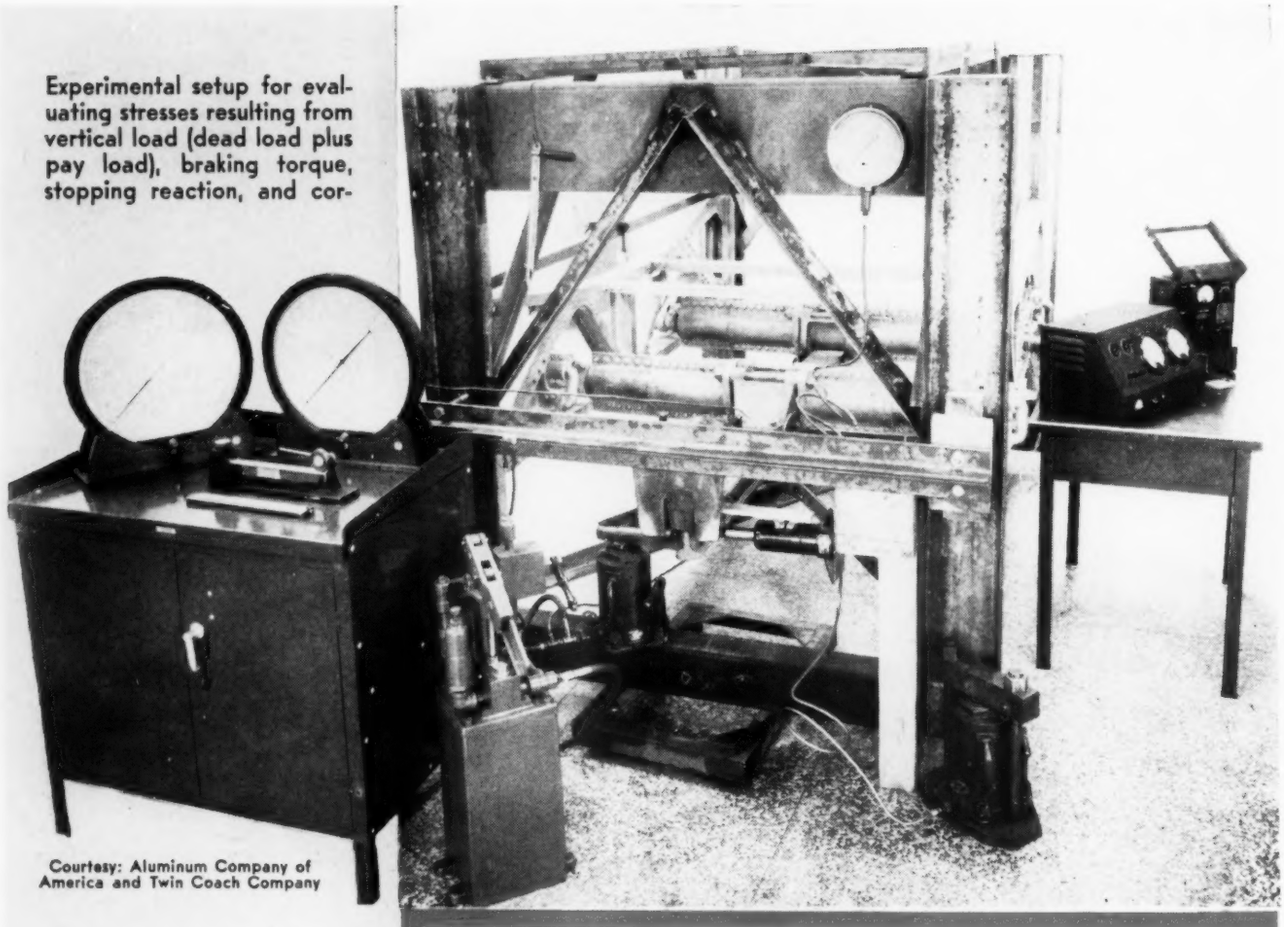


A symposium of case histories wherein the application of experimental stress analysis resulted in design improvements. Brief explanations of the brittle coating or Stresscoat technique and of the field of photoelasticity are included.

During the last decade the art of experimental stress analysis came to the forefront. Recognizing the limitations of the classical stress formulas, some of the leading engineers sought ways and means to determine the actual stress distribution and magnitude of stresses by tests on full size or scale models.

By 1938 the various techniques used in experimental stress analysis were in wide use. New fundamental design concepts revealed thereby indicated that here was a new design tool that will play a major part in future design development. Many of the engineers active in experimental stress analysis rightly felt that they should organize to provide a common meeting ground for the discussion of their problems and the presentation of new developments in the field of experimental stress analysis.

Thus it came about that in the spring of 1943 the Society for Experimental Stress Analysis was founded Indicative of the rapidly increasing importance attached to experimental stress analysis, the society grew rapidly and now has a membership of more than 1,000 and is supported by 30 company memberships. Its semi-annual publication, "Experimental Stress Analysis" presents outstanding accomplishments, new design concepts and new developments in the art of stress analysis.



Experimental setup for evaluating stresses resulting from vertical load (dead load plus pay load), braking torque, stopping reaction, and cornering reaction or different combinations thereof in a Torsilastic rear suspension assembly for a bus. The assembly consisting of aluminum alloy castings, forgings and rolled shapes is suspended in a steel structural frame. Stresscoat and resistance wire strain gages are used to evaluate stresses in different directions under various combinations of loads. Loading is applied by hydraulic jacks of different capacities. Valves are placed in the pipe lines so that the jacks can be used simultaneously to apply combined loads or so that each jack can be used separately to apply a single load. The load on each system of jacks is indicated by a precision gage. For accurate determination of loads, gage readings are compared with a calibration curve of each jack.

Courtesy: Aluminum Company of America and Twin Coach Company

BRITTLE COATING METHOD for Experimental Stress Analysis

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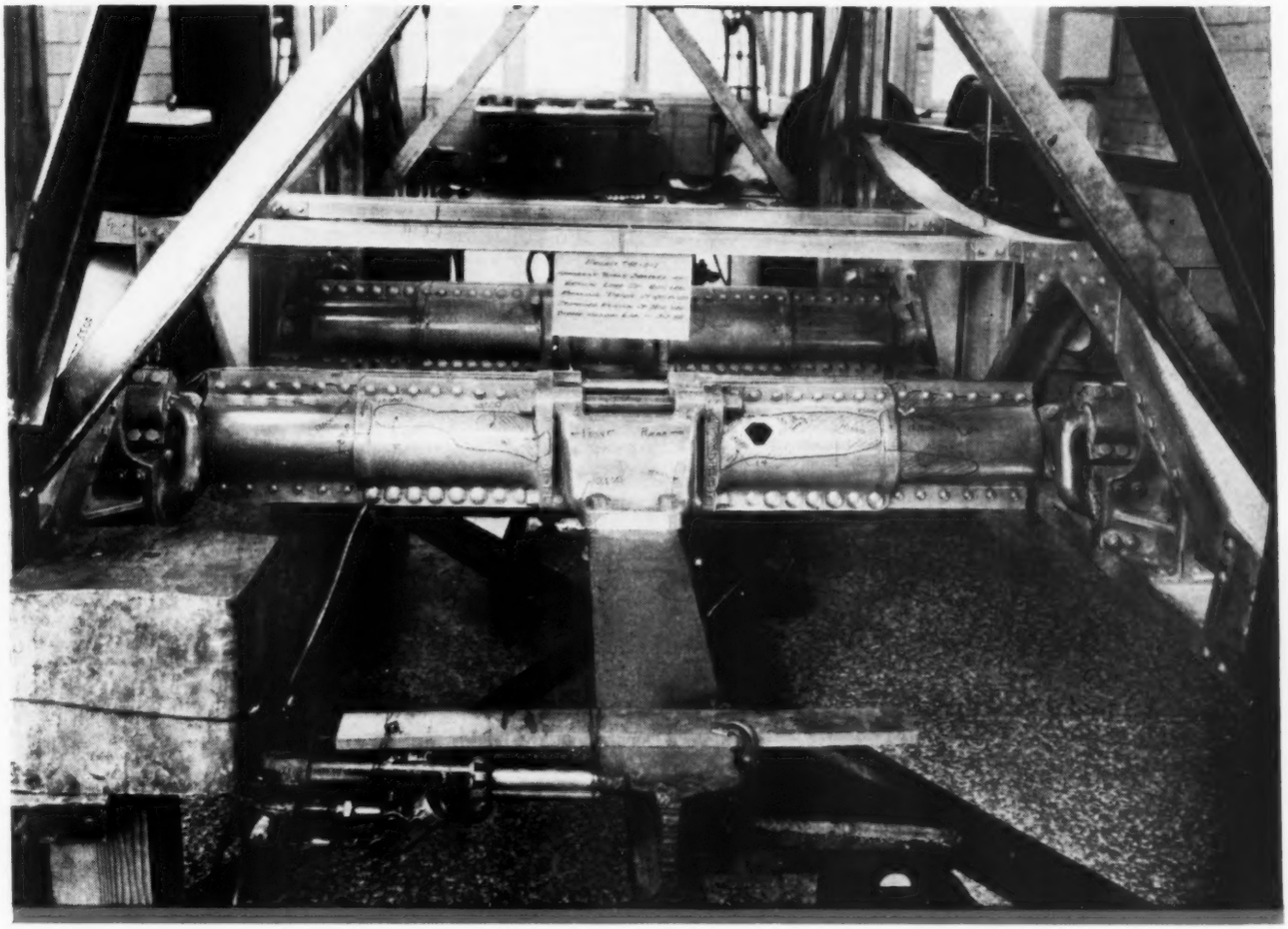
Engineer in Charge of Stress Analysis, Aluminum Company of America
Cleveland, Ohio

Development of brittle coatings make possible the detection of strain and evaluation of stress in critical regions of mechanical parts and assemblies. In experimental setups service loadings can be simulated by loads imposed by levers, hydraulic jacks and similar devices.



Courtesy: Aluminum Company of America and Twin Coach Company

After applying loads to the railroad rail, which simulates the bus axle, the stressed areas of the Torsilastic suspension assembly were outlined with crayon and marked to show the apparent stress (strain times modulus of elasticity). Directions of principal strain are shown by lines drawn parallel to the cracks in the Stresscoat. Strain gages and strain rosettes are applied at locations of interest for determining magnitude of indicated stresses resulting from vertical load, braking torque and stopping reaction.

STRESS ANALYSIS by the brittle coating method had its inception many years ago when investigators noticed the hairline cracks that are produced in the mill scale surface of ferrous parts in the regions of high stresses. Brittle coatings then developed to indicate regions of high stress, in general, were limited to detecting areas where the material had been stressed beyond the yield point and had flowed plastically. The methods did not give quantitative results nor was it possible to determine the relative magnitude of different strains, because of the lack of uniformity of the brittle coatings and shortcomings in the techniques employed.

Shortly before the war, Greer Ellis of the Massachusetts Institute of Technology announced and described a brittle lacquer method by which the magnitude and direction of principal tension and compression stresses can be determined. He gave it the name Stresscoat. This method overcame the shortcomings of the previous methods and gives quantitative values of principal stresses, both compression and tension. The basis of the method is a series of brittle lacquers, about ten, each suited for a specified range of temperature and humidity at which the test member is to be loaded. The series of lacquers covers the temperature range between 50 and 100 deg. F. The method is marketed now by the Stresscoat Division of the Magnaflux Corporation.

To measure the strains in a part by the Stresscoat method, the surface of the piece is thoroughly cleaned and sprayed with a thin coat of aluminum paint to increase the visibility of the subsequent Stresscoat patterns. The piece is then carefully sprayed with the brittle lacquer selected for the temperature and humidity range that will prevail during the application of the loads. At the same time, a cantilever calibration bar is treated in the same manner. Care is taken to make sure that the coatings on the calibration bar and on the piece tested are of about the same thickness, which may be from 0.003 in. minimum to 0.008 in. maximum, optimum thickness 0.005 in. The calibration bar and the machine part under test are loaded at approximately the same time to insure the same humidity and temperature conditions.

The crack patterns that develop in the Stresscoat are always at right angles to the direction of the principal stress or strain. Magnitude of strain is checked by noting the loads on the structure when the Stresscoat patterns first appear. The calibration bar tells the amount of strain that just starts the formation of patterns. Test loads are applied by any suitable means that simulates the loads that will be imposed upon the part when in actual service. Levers, hydraulic cylinders, and similar devices are used.

Because Stresscoat will respond to very rapid rates of loading, it is extremely useful on many dynamic problems, such as the firing of guns, where it is difficult to simulate service conditions by controlled static loads. Under service loading, quanti-

tative results of fair accuracy are obtained by repeating the same test with a coating that starts to crack at a different amount of stress each time.

Maximum accuracy is obtained when the stress is pure tension or pure compression, because Stresscoat is influenced by strain only. The apparent stress can be obtained by multiplying the strain by the modulus of elasticity of the material. Since the Stresscoat indications reveal the region and direction of the maximum principal strains, they thereby indicate where additional experimental stress analysis can be made by the application of strain gages.

Residual stresses developed during the manufacture of a part or during its subsequent assembly can be determined and evaluated on a qualitative basis with Stresscoat by a special technique. This method is based on the fact that the removal of a portion of a stressed part compels the remaining part to undergo elastic strain in order to reestablish the balance of internal forces. Drilling small holes in the stressed part, Fig. 1, is a simple and satisfactory method.

For accurate results by the Stresscoat method, the surfaces to which the lacquer coating is being applied must be clean, cleanliness must be thorough throughout the conduct of the test, and proper temperature relations must be maintained during the application of the load. The lowest strain that can be measured practically by the Stresscoat method is of the order of 0.00045 in. per in. This corresponds to a tensile stress of about 4,500 lb. per sq. in. in aluminum and 13,000 lb. per sq. in. in steel. With careful technique and for strains within the elastic range, the probable error in pure tension or compression stresses will be in the neighborhood of 10 percent.

Detailed directions and descriptions of the application of this technique can be found in the article, "Testing Designs of Machine Parts by the Brittle Lacquer Method," PRODUCT ENGINEERING, October, 1943, in the *Transactions* of the Society for Experimental Stress Analysis, and in the operating instructions for the use of Stresscoat, distributed by the Magnaflux Corporation.

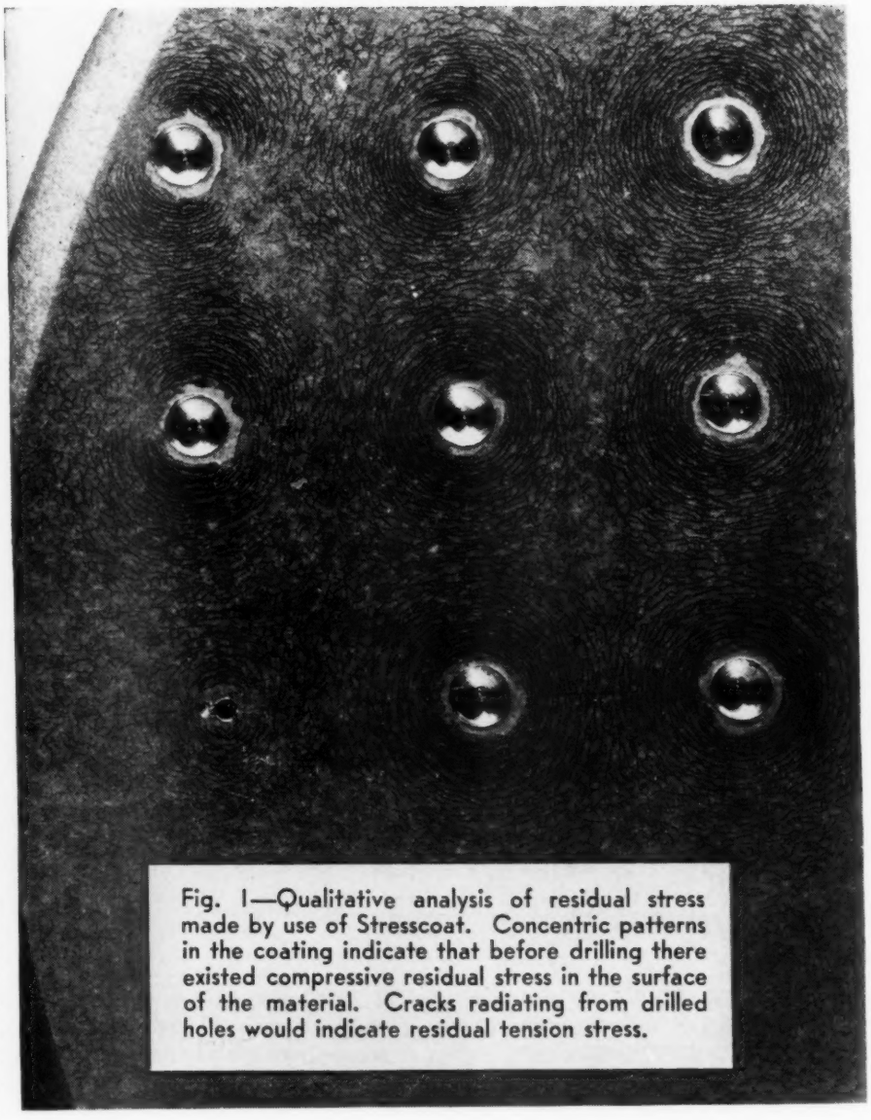


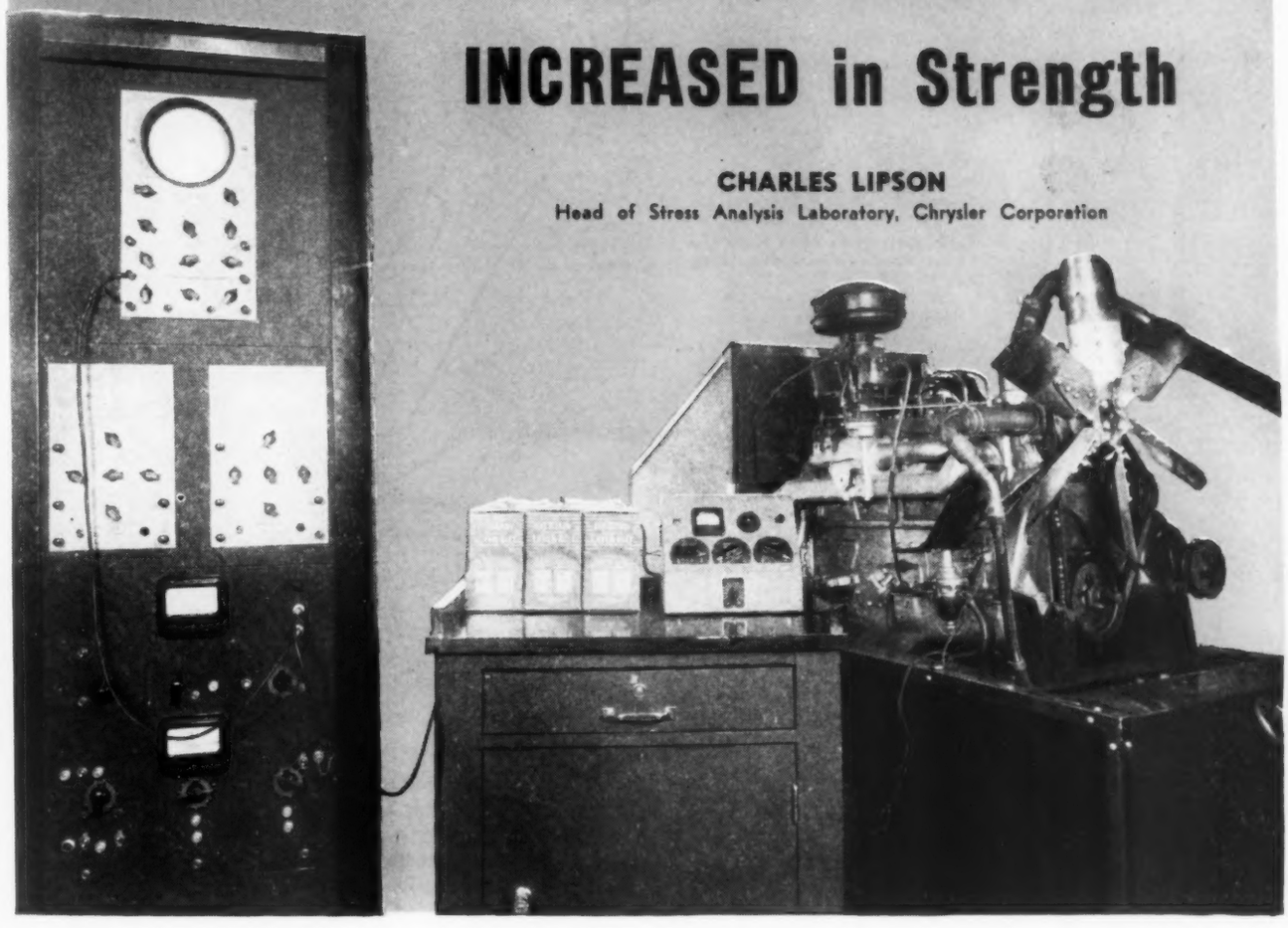
Fig. 1—Qualitative analysis of residual stress made by use of Stresscoat. Concentric patterns in the coating indicate that before drilling there existed compressive residual stress in the surface of the material. Cracks radiating from drilled holes would indicate residual tension stress.

Courtesy: Aluminum Company of America and Twin Coach Company.

Areas of high stress around the shackle support have been indicated by means of Stresscoat. Slight modifications in design can be made that will improve the load-carrying ability of this assembly. The relative amount of improvement can be evaluated by repeating the previous test upon the modified design.

Truck Fan REDUCED in Weight And INCREASED in Strength

CHARLES LIPSON
Head of Stress Analysis Laboratory, Chrysler Corporation



By means of an experimental stress analysis, the weight of a standard production fan through redesign was reduced almost 27 percent and its strength increased 30 percent without changing its air flow characteristics.

OBJECT of this investigation was to reduce the weight of a standard truck fan without loss in strength or in air flow characteristics.

The fan as originally designed, Fig. 1, weighed 8.2 lb. This fan was Stresscoated, mounted on an engine and run at speeds sufficient to give a recognizable stress pattern and thus indicate critical stress regions. After which, fourteen wire strain gages (seven on each side) were mounted on the blade and the spider, in locations corresponding to the critical stress regions. In the experimental set up, the leads from the gages were brought out to the measuring and recording instruments through slip rings installed under the fan pulley.

Strain gage measurements of the fan in rotation were then conducted in two phases: (1) Steady stress determination. (2) Fluctuating stress determination.

STEADY STRESS DETERMINATION. An analysis of data derived from gages attached at the region of maximum stress (at the spider, slightly below the double rivet line) showed that on the intake side of the fan the stress was compressive, while on the discharge side the stress was tensile. In addition, the tensile stresses were higher than the compressive stresses. This indicates that in operation the fan is subjected to combined tensile and bending stress resulting from a centrifugal and a thrust loading. The bending component of stress and the tensile component of stress, as indicated by one gage, is shown in Fig. 2. Also shown in Fig. 2 is the tensile stress curve calculated from the effect of the centrifugal load alone, this curve checking satisfactorily with the measured values.

This investigation indicated that the measured stresses were as much as five times the theoretical stresses calculated on the basis of pure tensile loading from a centrifugal force. At most of the critical points, 90 percent of the combined stress was caused by bending loads. There were two contributing factors for this phenomenon:

1. The eccentricity of the center of mass of the blade from the center of support for the spider arm, an inherent characteristic of the shape of the fan.
2. The curvature of the spider at its leading and trailing edges that is incurred in twisting the spider arm to give the blade the proper angle of attack.

FLUCTUATING STRESS DETERMINATION. At the outset of the investigation, there

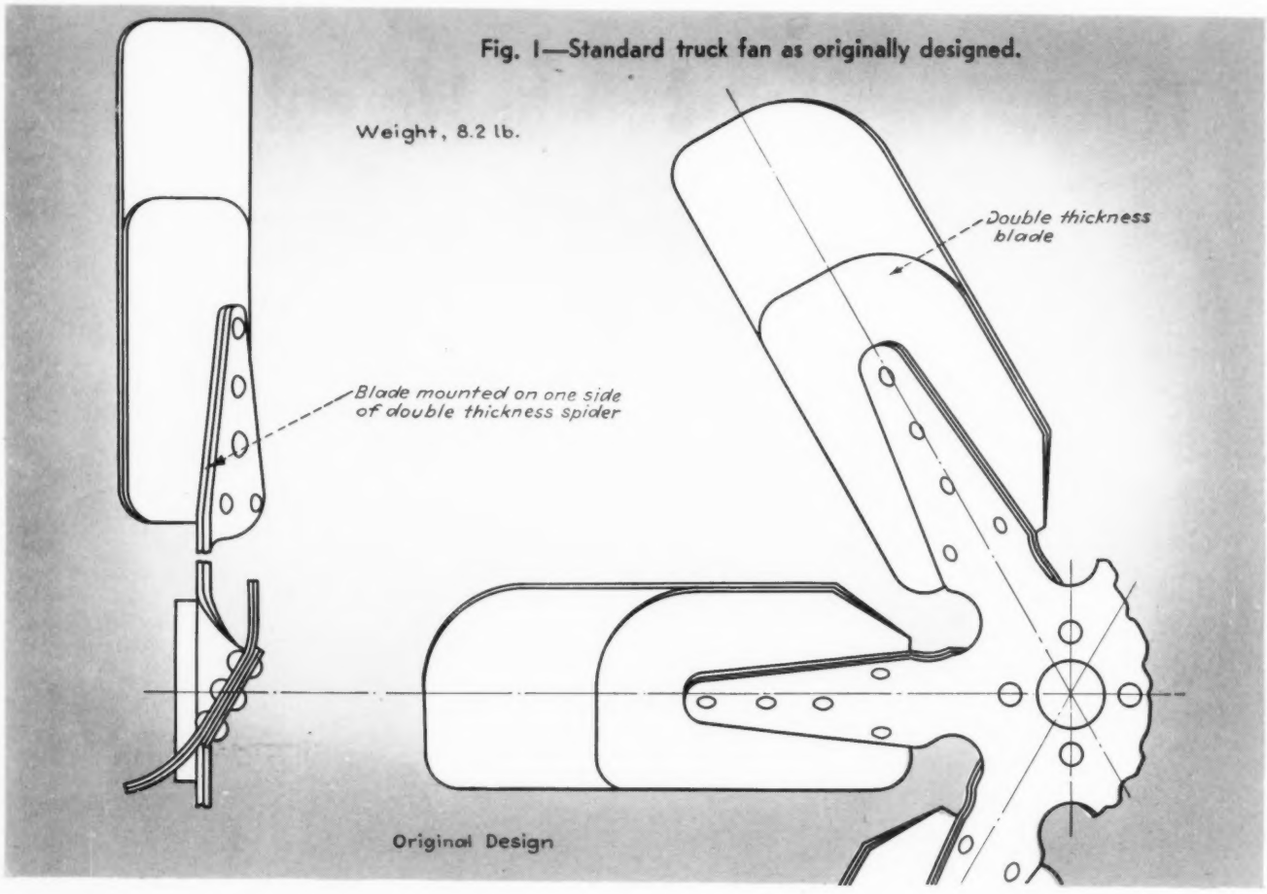


Fig. 1—Standard truck fan as originally designed.

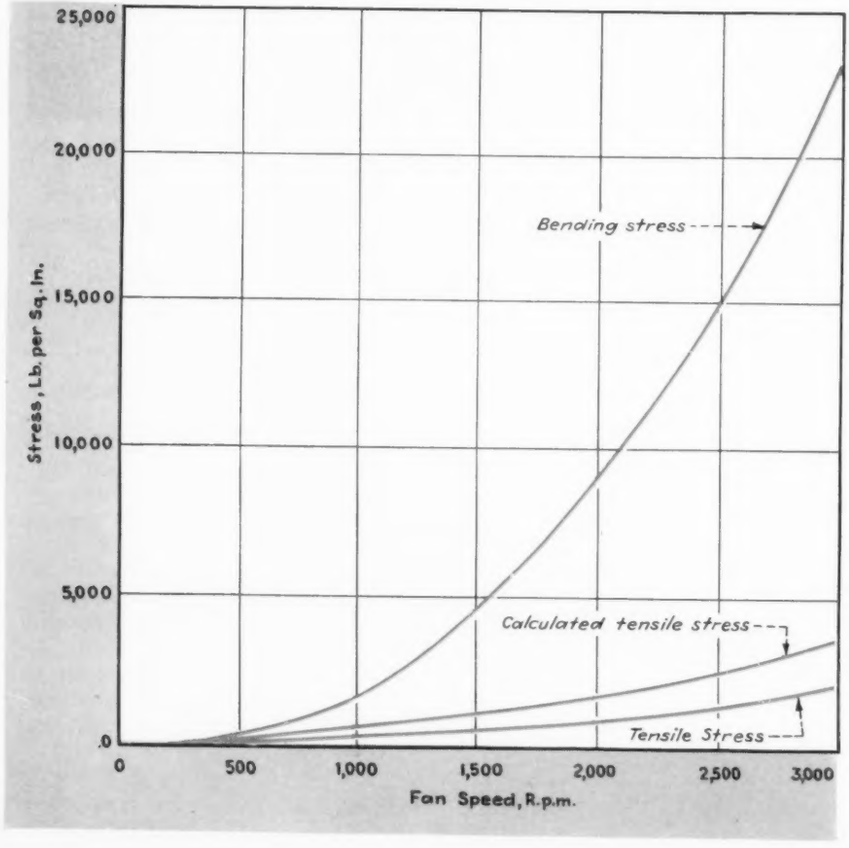


Fig. 2—Bending stress and tensile stress components as indicated by strain gage on rotating fan.

was reasonable doubt as to the existence of fan flutter. For that portion of a revolution in which a fan blade passes in front of the engine, the discharge side of the blade is subjected to pressures that are higher than those encountered throughout the remainder of the revolution where there are no air restrictions. A periodic force of this nature would probably consist of a fundamental wave and many harmonics. Consequently, a flutter stress peak would be expected at the resonant speed of every harmonic until the fan speed exceeds the natural frequency of the fan.

At periods of resonance between the exciting force and the natural frequency of the fan, the stress fluctuations are large. Fig. 3 shows the stress fluctuations, as indicated by the gage attached to the region of maximum stress, superimposed on the mean stress. Similar peaks were observed at engine speeds up to 4,500 r.p.m., the maximum speed attained in the investigation.

In a separate step in the investigation, the natural frequency of the blades in simple bending was found to be 117 cycles

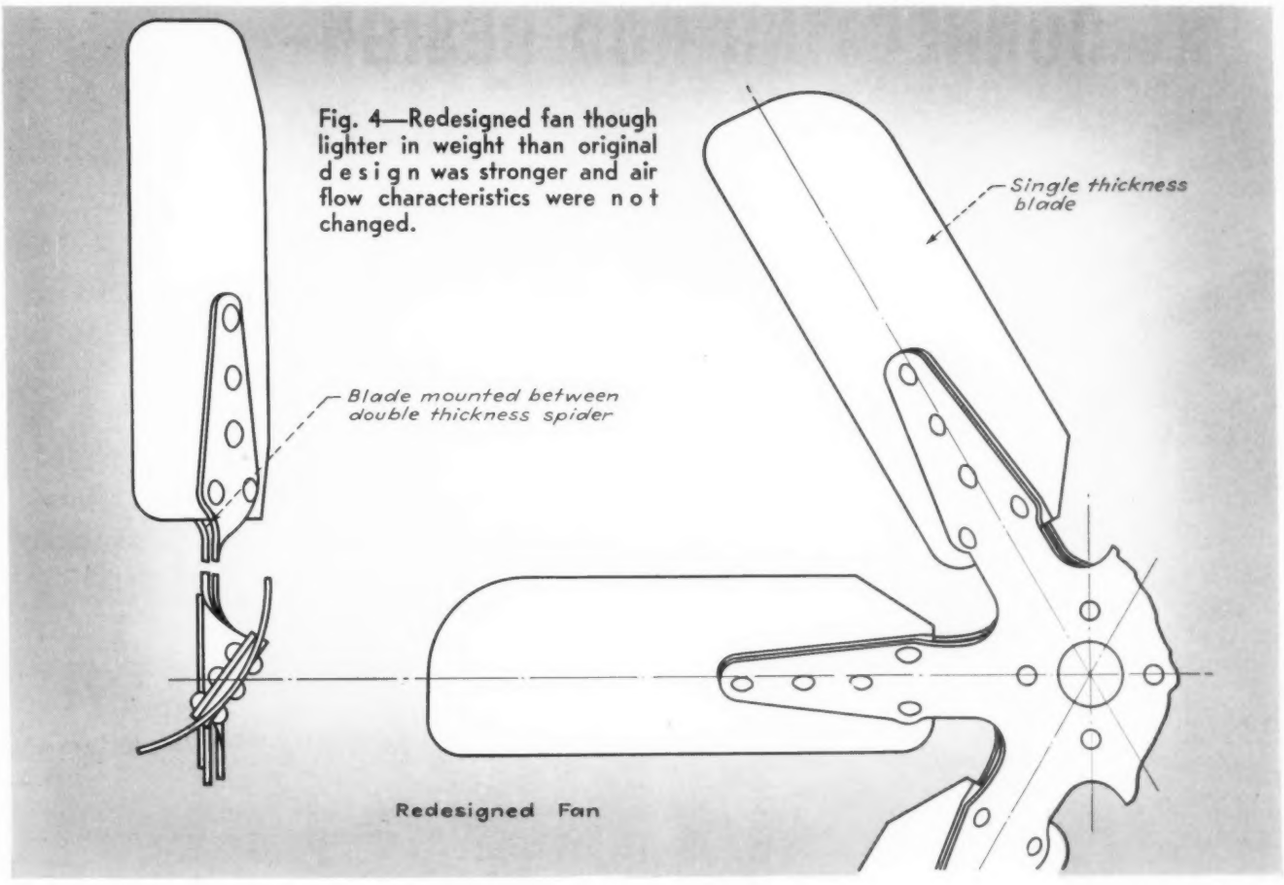


Fig. 4—Redesigned fan though lighter in weight than original design was stronger and air flow characteristics were not changed.

per sec. and the damping was found to be approximately 200 percent of that expected in a cantilever made of solid steel.

The investigation indicated that the strength of the fan is affected by:

1. Damping between the spider arms, which governs the magnitude of the fluctuating component of stress.
2. Weight of the blades, which affects both the static and the fluctuating stress.
3. Section modulus in bending at the double rivet line, which is an inverse function of both components of stress.

The fan as redesigned is shown in Fig. 4. This fan had larger damping between the spider arms (250 percent of the cantilever and natural frequency of 135 cycles per sec.), lower blade weight and a larger section modulus at the double rivet line. While this fan weighed only 6 lb., it was found to be stronger than the standard 8.2 lb. fan, both in respect to the overall stresses and their uniformity across the spider width. At the critical region, slightly below the double rivet line, the maximum stress was 30 percent less than in the standard fan.

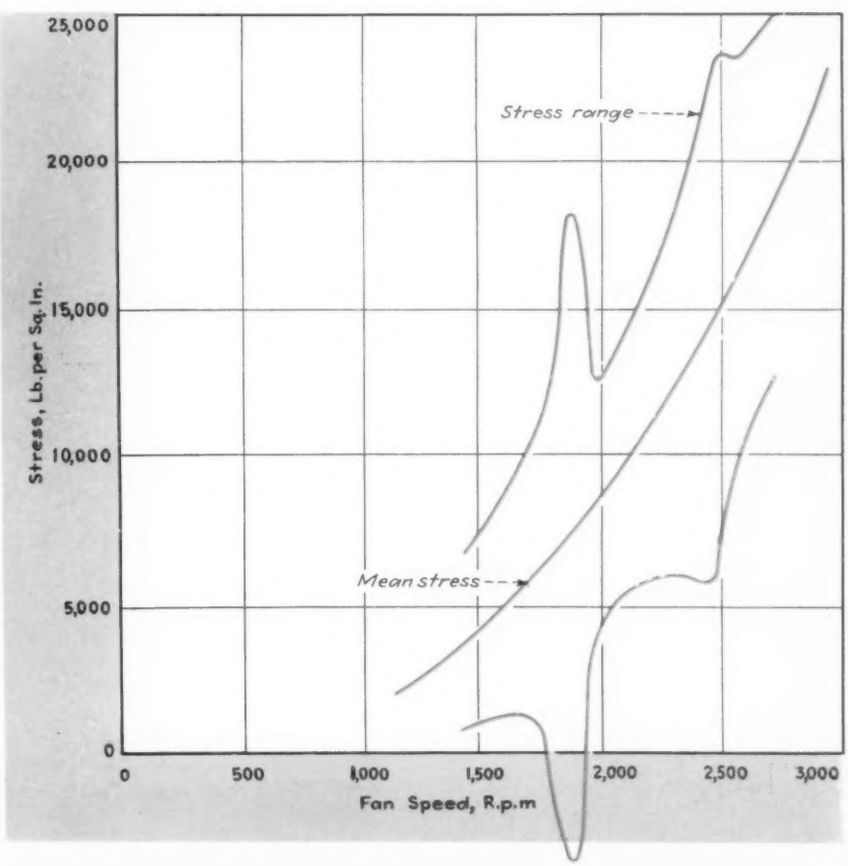


Fig. 3—Stress fluctuations in rotating fan as indicated by the gage attached to the region of maximum stress.

CONNECTING ROD DESIGN Improved Through Brittle Lacquer Testing

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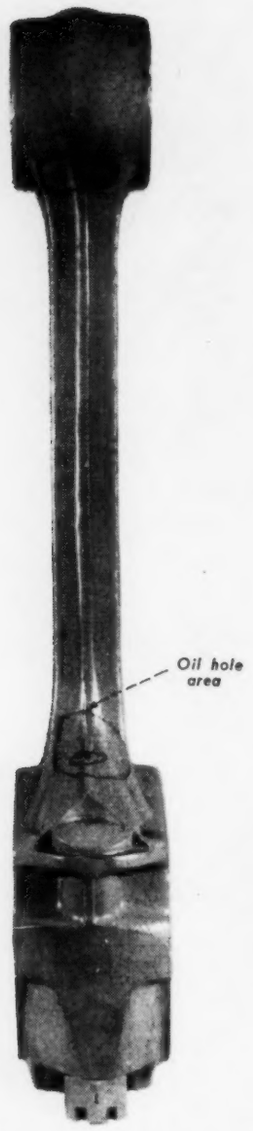
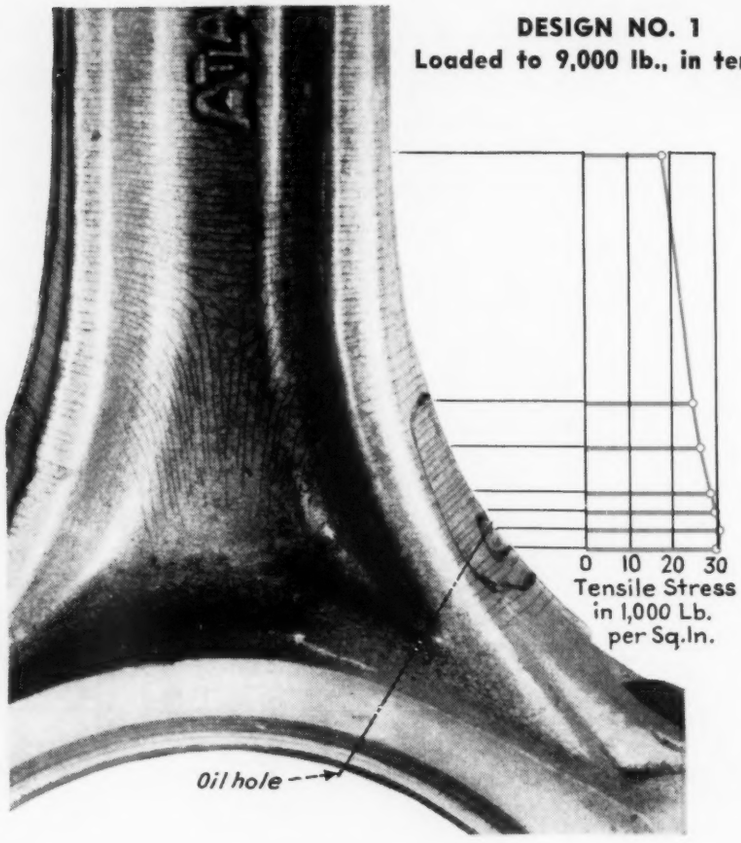
Continental Aviation and Engineering Corporation

A service failure of an automotive type connecting rod indicated that its weakest section was at the oil hole in the crankpin end. Analysis of the failure showed that the critical stress was caused by a tension load resulting from inertia forces.

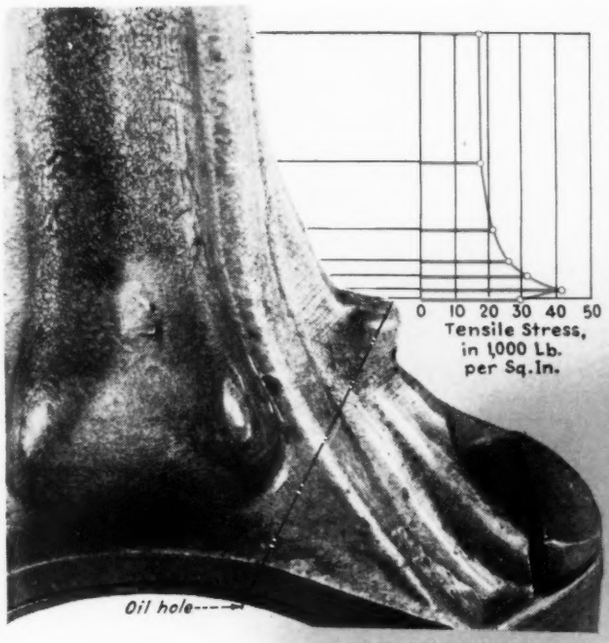


ROD AS ORIGINALLY DESIGNED. From a crankpin bearing polar diagram, made for an engine speed of 3,000 r.p.m., a tensile load of 9,000 lb. was selected as maximum value for test loading the connecting rod. Encircled areas on Stresscoat locate the first indications of strain as tensile load, applied by hydraulic machine, progressively increased from zero to 9,000 lb. Stresscoat tests confirmed the assumption that stresses were concentrated near the oil hole in the crankpin end of rod.

DESIGN NO. 1
Loaded to 9,000 lb., in tension

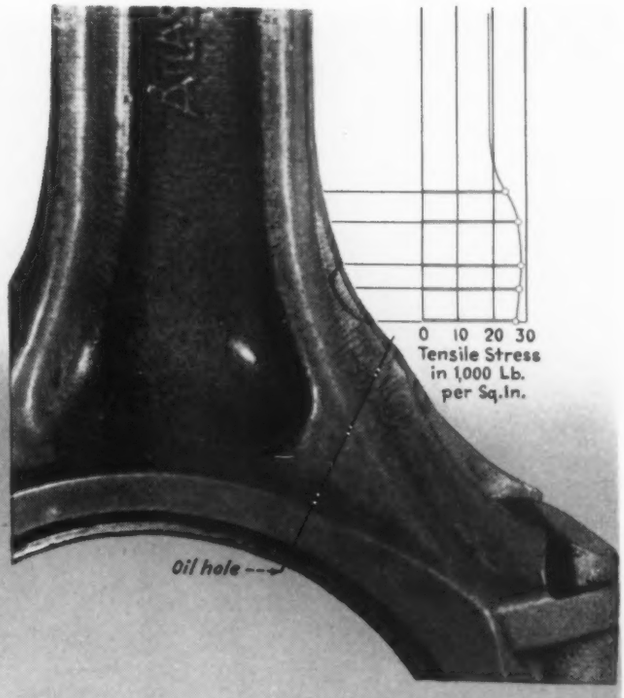


GRAPH gives quantitative values of stress, derived from extensometer measurements, at points in vicinity of oil hole. A stress of 31,000 lb. per sq. in. is indicated near oil hole. Extensometer values are roughly indicated by density of the cracks in the Stresscoating. The cracks form perpendicular to the principal tensile strains. Notice the direction of the cracks at the root of the web. Tension here changes from the lengthwise to crosswise direction, because the inertia load is attempting to pull the connecting rod ribs straight.



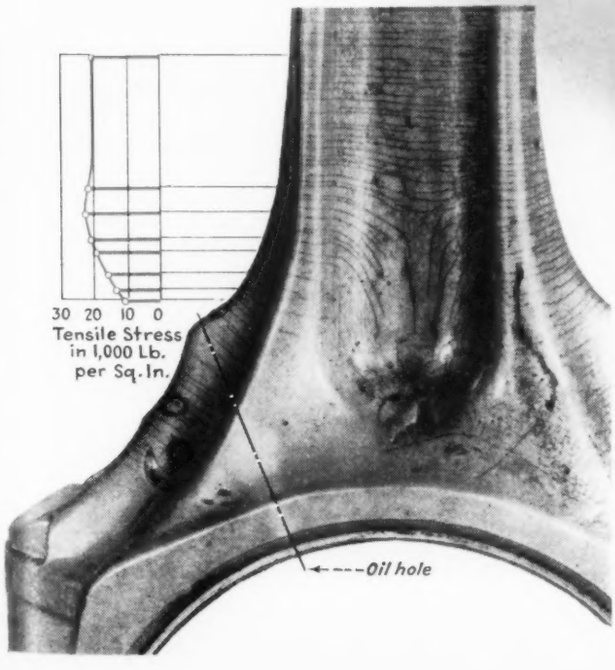
DESIGN NO. 2—Loaded to 9,000 lb., in tension

In Design No. 2 an attempt has been made to strengthen the rod by adding a boss at the oil hole where stress was greatest in the original design. The results can be seen on the stress chart. The maximum stress in this design is no longer at the oil hole, but in the area just above the oil hole where there is an abrupt change of section. This stress of 41,000 lb. per sq. in., an increase of 32 percent more than the maximum stress in the original design, clearly emphasizes that an addition of metal not only may fail to reduce stresses, but if incorrectly distributed may increase them.



DESIGN NO. 3—Loaded to 9,000 lb., in tension

In Design No. 3 of the connecting rod, metal was removed from Design No. 2 in order to form a gradual change of section in the vicinity of the oil hole. Stresscoating and an extensometer survey indicated that this change in design shifted the area of maximum stress to a region about half an inch above the oil hole. The maximum stress is 28,000 lb. per sq. in., a slight reduction from that of the original design, and the oil hole does not enter the maximum stressed area. A concentration of stresses along the oil-hole rib is clearly indicated by the graph.

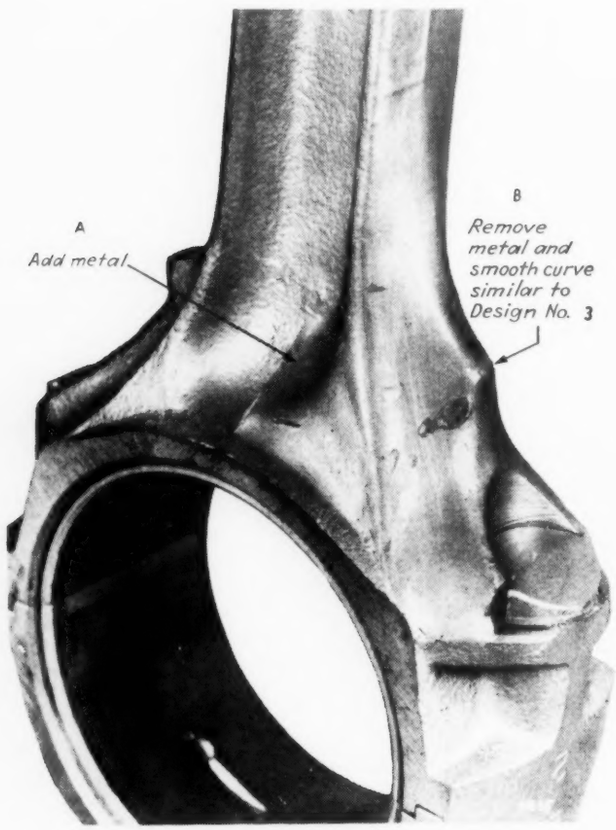


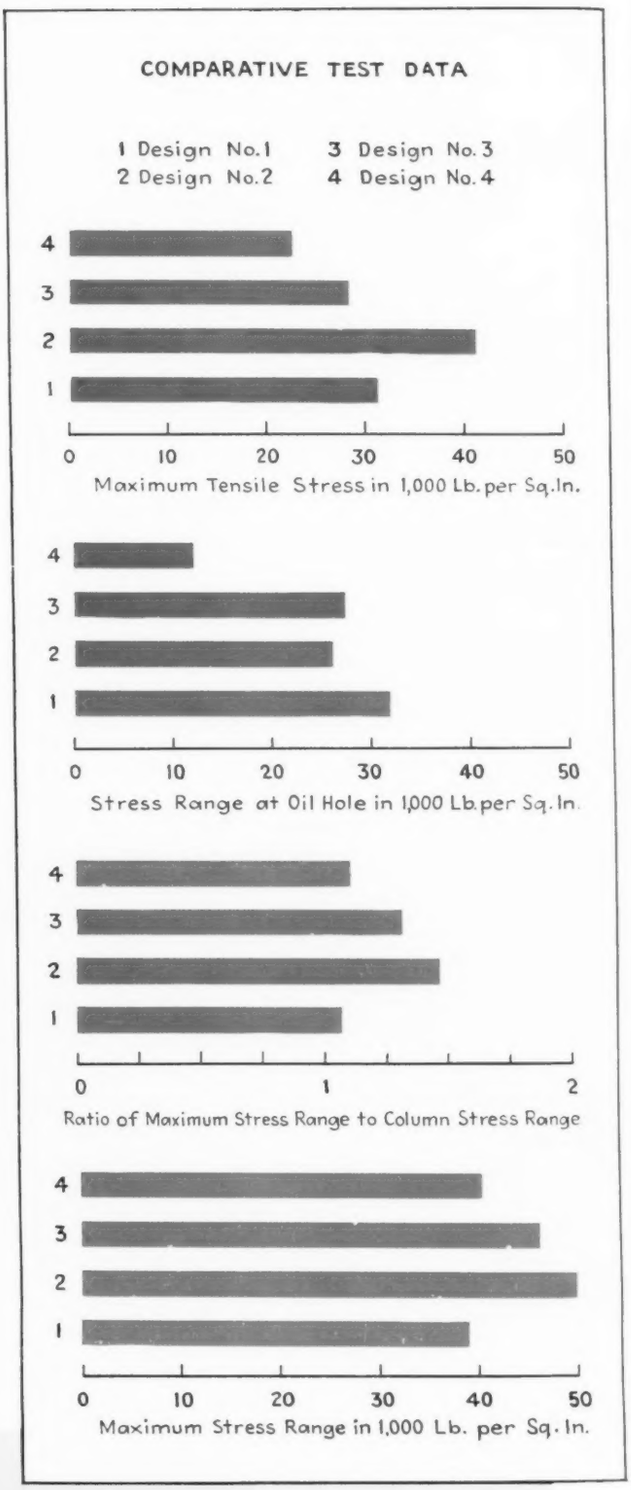
DESIGN NO. 4—Loaded to 9,000 lb., in tension

Design No. 4 of the connecting rod includes a more gradual blending of the oil-hole rib than in the previous designs, plus the addition of metal at the oil hole and at the web root. The Stresscoat pattern showed that the region of maximum stress is well above the oil hole. The extensometer survey indicated that the maximum stress is only about 22,000 lb. per sq. in. Stresses at the oil hole have been reduced to a value so small that they need not be considered. Note how additional metal filled in at the web root has reduced the lateral tensile stress in the cross-sections at the end of the web.

Analysis of the failure under load in any one direction, even in the direction of maximum stress, was not an adequate examination of the connecting rod, because of the cyclical reversal of the stress. Such reversals cause fatigue failure if

the stress range is too high. Therefore a knowledge of stress ranges is particularly important for this design. In addition to the tensile tests, each of the four designs described was subjected to compression and bending tests. The stress ranges in tension and compression for the different designs are compared in the accompanying bar chart. On Design No. 1 the stress range at the oil hole area is 31,800 lb. per sq. in. The maximum stress range is 39,000 lb. per sq. in. Notice that Design No. 4 reduces the stress range at the oil hole area to 12,000 lb. per sq. in., although the maximum stress range is increased slightly, 40,400 lb. per sq. in., but this range of stress occurs about 1¾ in. above the bearing shell in a non-critical area of the connecting rod. It is evident then, that Design No. 4 is more desirable.




COMPARATIVE TEST DATA
1 Design No.1
2 Design No.2
3 Design No.3
4 Design No.4
Maximum Tensile Stress in 1,000 Lb. per Sq.In.
Stress Range at Oil Hole in 1,000 Lb.per Sq.In.
Ratio of Maximum Stress Range to Column Stress Range
Maximum Stress Range in 1,000 Lb. per Sq.In.

CONCLUSIONS

On the basis of these tests several design changes were recommended for the modification of the die used to forge the connecting rods. The modifications suggested for the crankpin end of the rod are shown in the above figure. It was recommended that metal be added as shown at Point A, but that metal be removed at Point *B* to produce a smooth curve similar to the Design No. 3. It should be noted, however, that metal has been added to the fillet of the entire oil-hole rib.

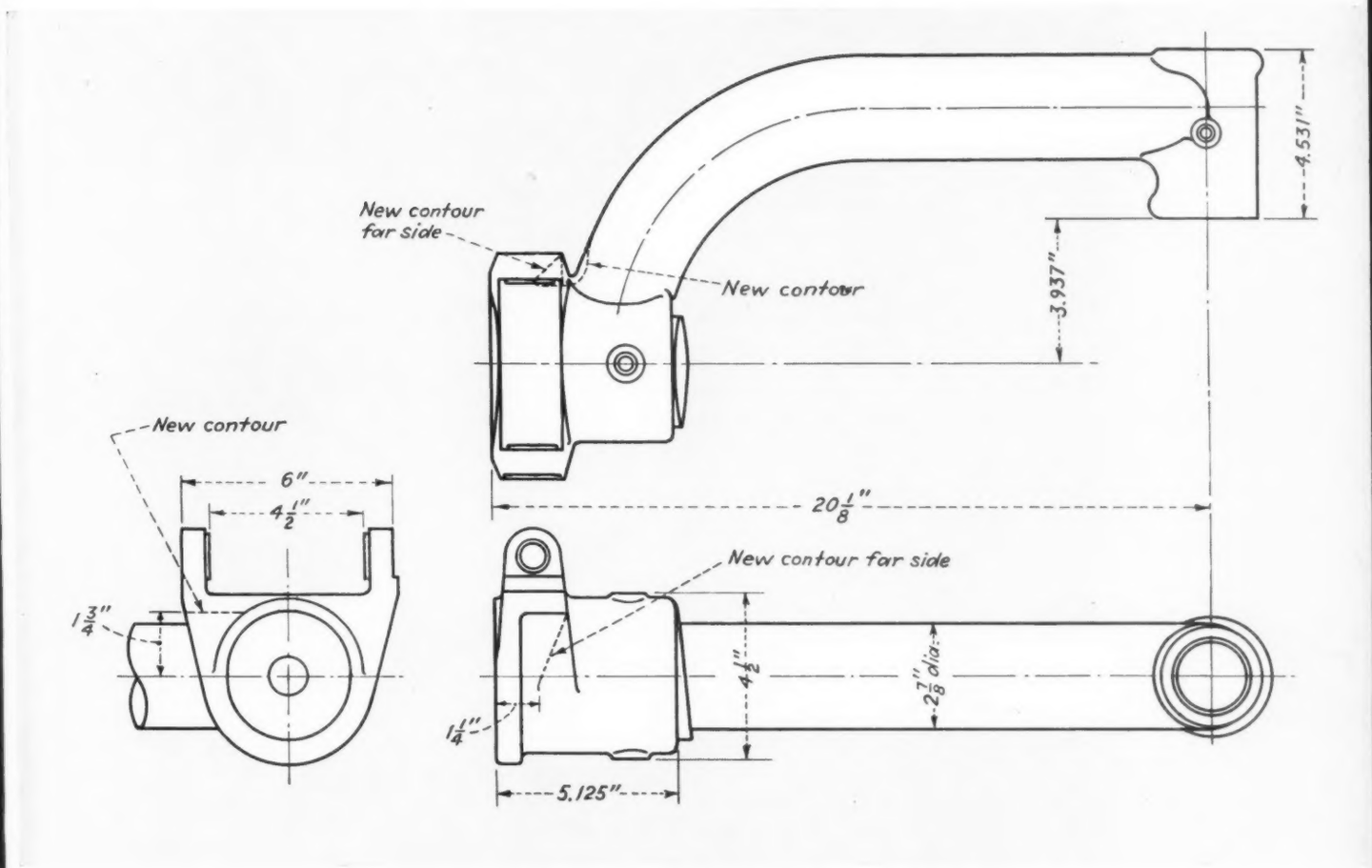


Fig. 1—Standard and modified designs of aircraft nose landing gear fork forgings that were tested under repeated impact loading.

IMPACT STRENGTH INCREASED

By Removing Material

Abstracted from a report prepared by the Structures Research Group of Lockheed Aircraft Corporation. Only the impact tests are described here. The complete investigation included also static tests and tests on parts that had been cracked in service.

STANDARD nose landing gear fork, a 14ST forging, used on the Model P-38 airplane, is shown by solid lines in Fig. 1. Progressive crack formation caused by side loads, occurred at the sharp notch at the junction of the shank with the cylindrical "socket" portion. Tests were made to determine what effect removing material to relieve the notch effect would have in improving static strength, impact strength and endurance under repeated impact loading. New contours are indicated with dash lines on drawing.

Static tests to obtain load-deflection curves were made, and tensile test coupons were cut from each specimen. Correlation of static tests with impact tests indicated that under the impact blow of a 117.5 lb. ram dropped from a height of 24.1 in. the specimens were stressed to the elastic limit. The final redesign, wherein the

sharp notch was relieved by removing material, has a life of 10 to 20 times that of the original design when subjected to repeated impact loads that stress the material to its elastic limit.

Machine on which impact tests were conducted, Fig. 2. A freely falling 117.5 lb. ram slides in the vertical superstructure. The ram is raised by compressed air through a cylinder and piston controlled by a 4-way hand-controlled valve. An "ice-tong" mechanism automatically picks up the ram and releases it when raised to the desired height. A Veeder counter mounted on the pivoted beam recorded the number of cycles.

Close-up of the mounting of the nose landing gear fork in the impact testing machine, Fig. 3. A solid bar of X4130 steel was machined, with about 1½ thousandths of an inch negative clearance, down to the outside diameter of the shock strut piston to mate with the socket of the fork forgings. To facilitate assembly, the forgings were expanded by heating at 212 deg. F. and then shrunk on the supporting bar. The bar was held in the welded frame that formed the base of the testing rig. This base was also used to hold the test specimens during static tests that were conducted on a 300,000 lb. testing machine. In the impact tests, the vibrations of the fork were recorded on a smoked glass plate by a stylus attached to the fork.

Typical smoked glass record of deflections, Fig. 5. When the ram was dropped the fifth, sixth and seventh times, the glass was moved laterally to obtain the complete record of the amplitude of the vibrations of the specimen, and the number and magnitude of the rebound blows.

Results of impact tests on fork made to original design, and one with the sharp notch modified, Figs. 4 and 6. Both specimens were subjected to increasing blows starting with a drop of the falling ram of 3.1 in. and each successive drop increased 3 in. Specimen 3 failed at the fifteenth cycle, 45.1 in. drop; this failure resulted largely from tension. Specimen 4 failed at the twenty-fifth cycle, 75.1 in. drop; the fracture ran vertically through the wall of the socket, as if caused by hoop tension.

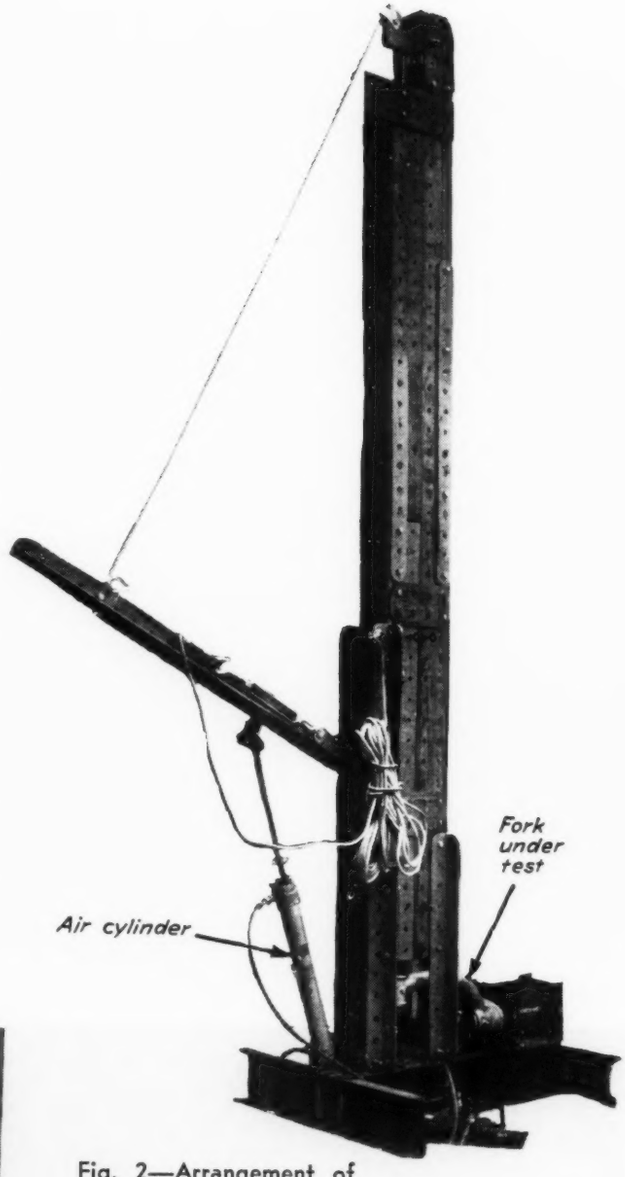


Fig. 2—Arrangement of apparatus for impact test.

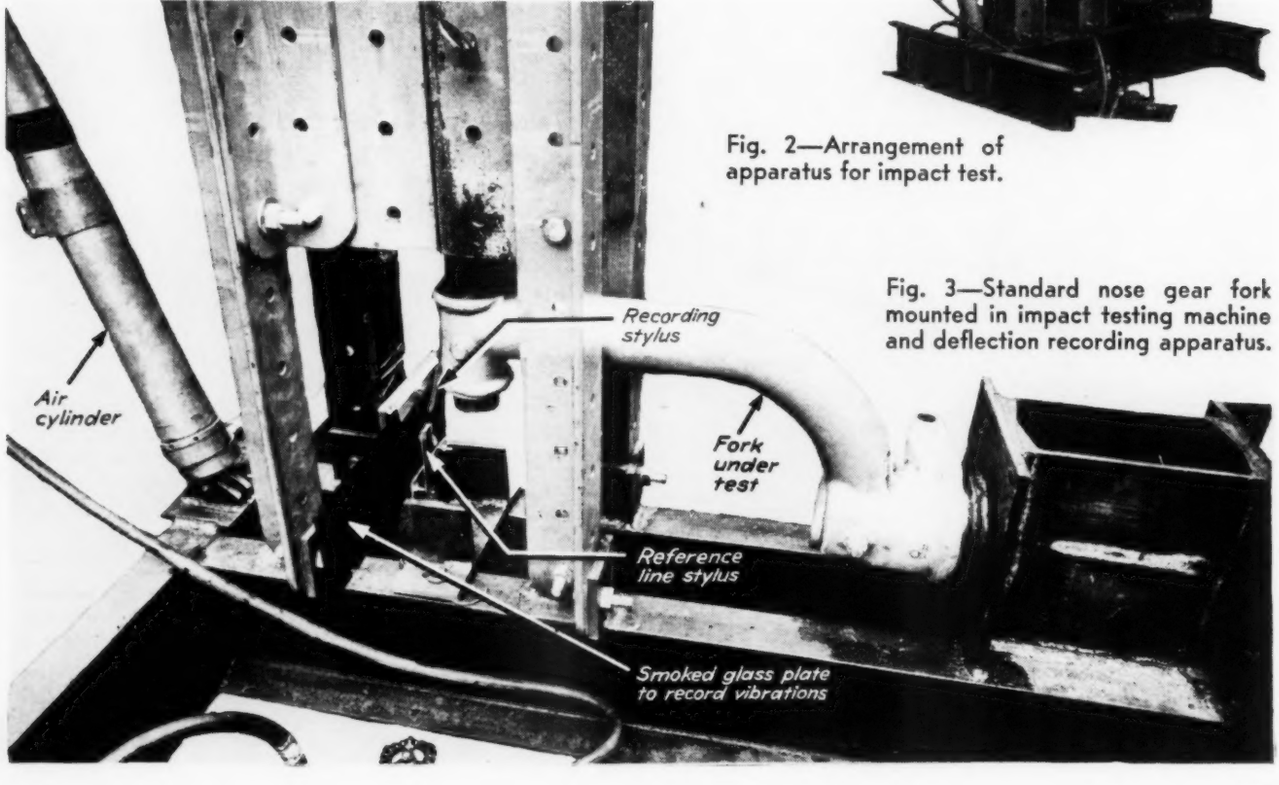
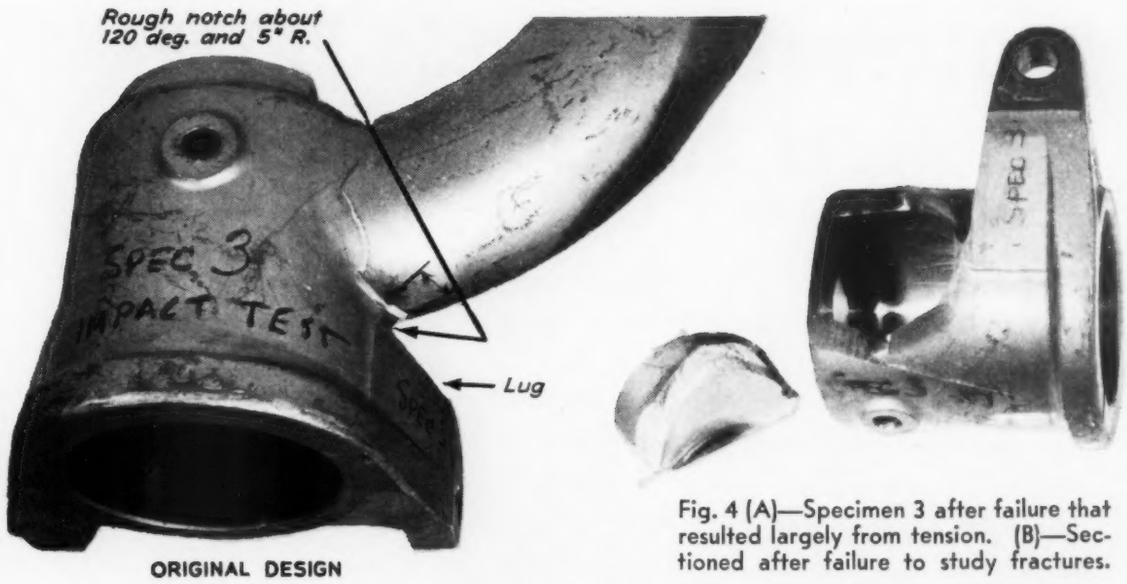


Fig. 3—Standard nose gear fork mounted in impact testing machine and deflection recording apparatus.



ORIGINAL DESIGN

Fig. 4 (A)—Specimen 3 after failure that resulted largely from tension. (B)—Sectioned after failure to study fractures.

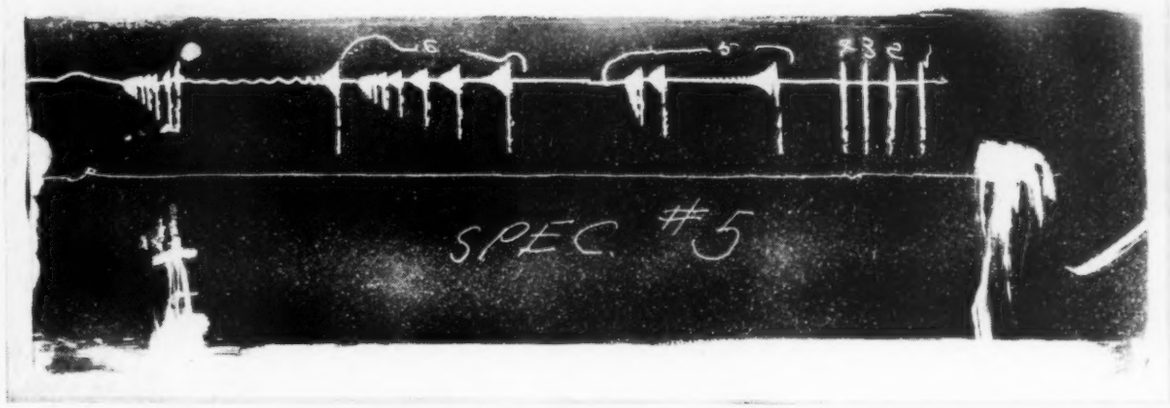


Fig. 5—Smoked-glass record of deflections of gear fork in impact test.

MODIFIED DESIGN

Fig. 6 (A)—Specimen 4 after failure probably caused by hoop tension. (B)—Sectioned after failure to study fractures.

PHOTOELASTIC STRESS PATTERNS Evaluate Stress Concentration

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Massachusetts Institute of Technology

For certain types of two dimensional and three dimensional problems, the use of polarized light on models made of suitable transparent material affords an extremely powerful and valuable means of studying stress distributions, especially in forms of odd or irregular contour. In common with all other methods of stress measurement, photoelasticity has some definite limitations. It possesses also certain characteristics that give it decided advantages under special circumstances.

CHIEF among the advantages of photoelastic studies is the overall stress picture or pattern. The typical photoelastic stress pattern shown in Fig. 1 is characteristic of the method. Such a diagram can be interpreted either qualitatively or quantitatively. By a mere visual observation of the stress pattern, one can locate the regions of high stress by noting where the lines, isochromatics, are crowded together. If a quantitative determination is required then the isochromatics must be counted from some reference that has been established in the laboratory. Frequently, the qualitative examination is quite sufficient to indicate the manner in which the design should be changed to reduce the peak stress. Any redistribution of stress caused by such changes, of course, can be checked by the relatively simple process of fashioning a new model in the soft plastic material, or on some models by simply changing its contour with a file.

Usually one considers a stress analysis for the purpose of establishing the value of the maximum stress, but in many designs the determination of regions of low stress is equally important when the purpose of the analysis is to avoid the use of unnecessary material. The corresponding reduction in weight is of particular importance in aircraft and in rapidly moving

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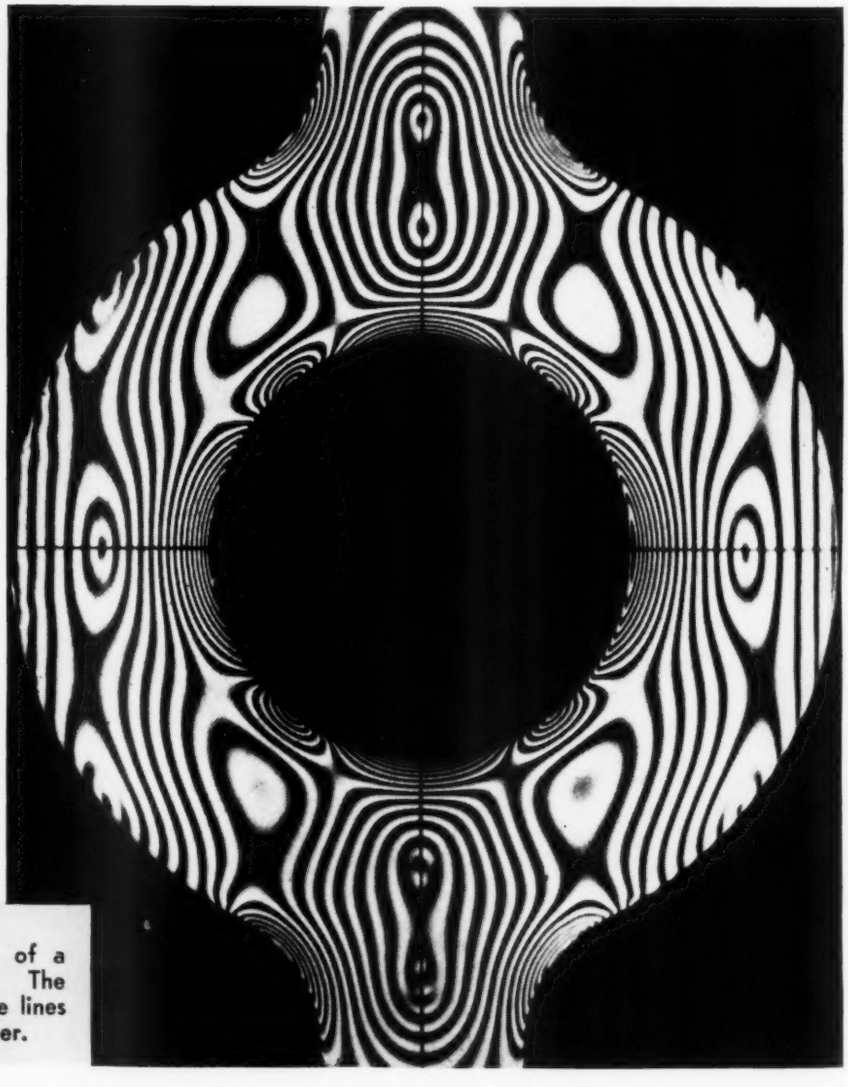


Fig. 1—Photoelastic stress pattern of a double ended eye bar in tension. The regions of high stress are where the lines of the pattern are crowded together.

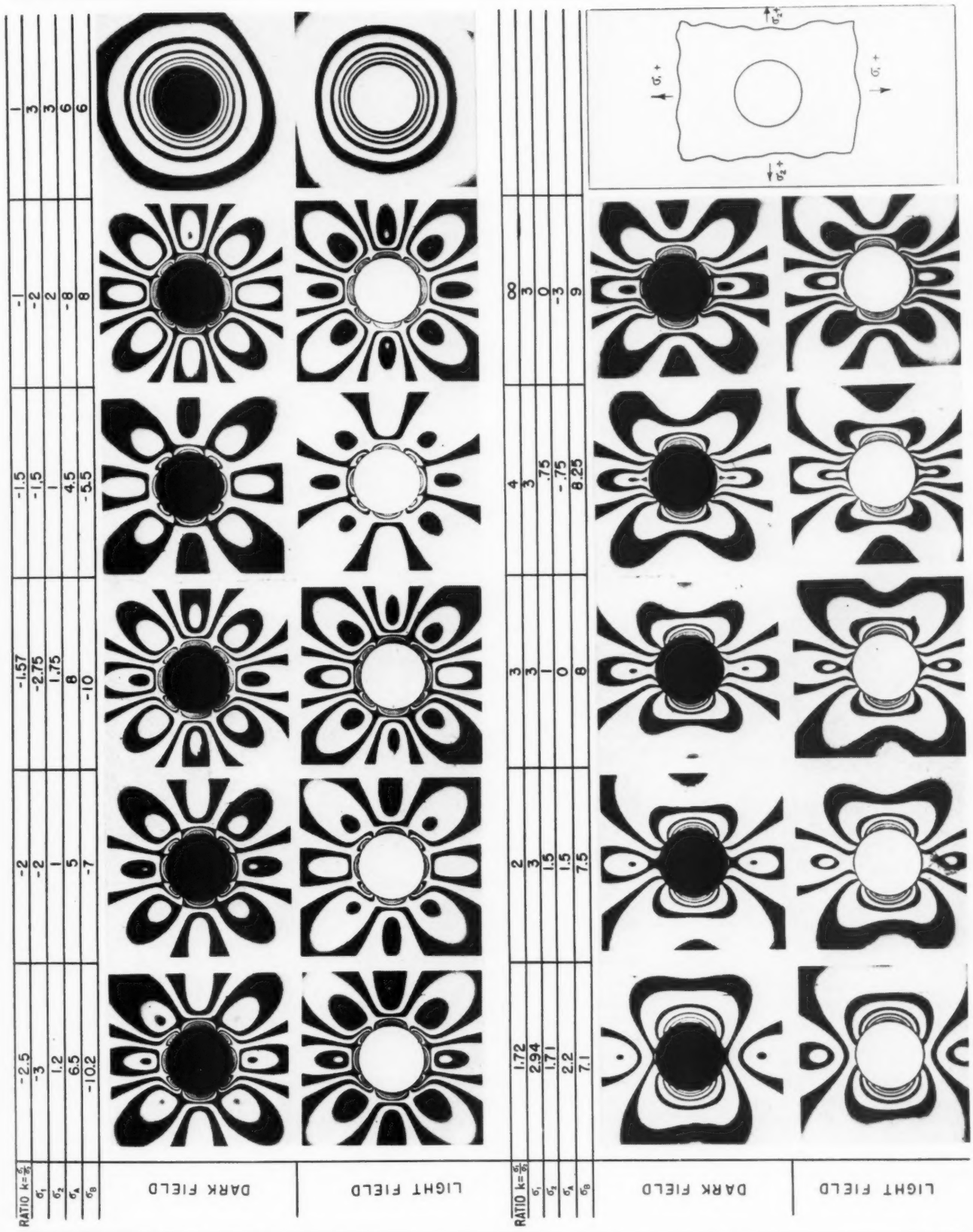


Fig. 7—Photoelastic stress patterns around a hole in a plate subjected to various conditions of uniform biaxial stress away from the holes.

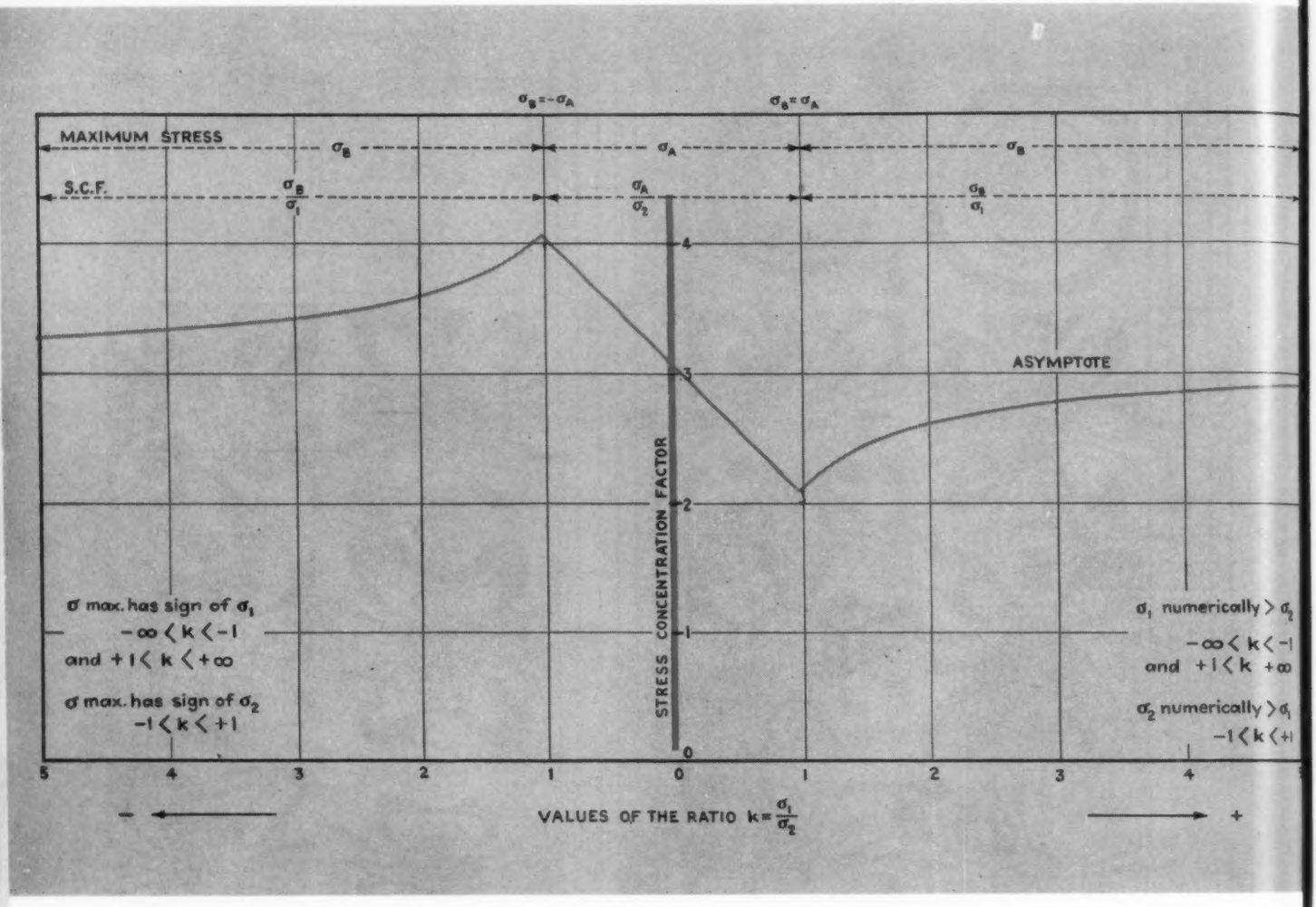


Fig. 3—Stress concentration factors as a function of the ratio of the principal stress intensities at points remote from a circular hole in a plate subjected to various conditions of biaxial stress.

machinery where parts may have high inertia forces.

Unlike most other means of measuring stress, photoelasticity is capable of establishing the value of a stress at a point, and, in this respect is equivalent to a strain gage of zero length. This ability makes the method admirably suited to the evaluation of stress concentration factors, which depend upon a precise knowledge of the actual peak stresses prevailing. Thus, photoelasticity provides a useful link between simple mathematical computation and actual design conditions. The engineer is fortunate; since for his convenience there are now available tables and charts of stress concentration factors for a wide variety of conditions.

Since this optical method of analysis yields results in close agreement with the mathematical theory of elasticity, when conditions are comparable, one can be confident of its reliability for those conditions that do not lend themselves conveniently to mathematical corroboration.

To demonstrate the close agreement between theory and experiment, the stress conditions prevailing around a circular hole in a flat plate subjected to a variety of uniform biaxial stress conditions are shown in Fig. 2. The symbol k represents the ratio of the principal stress intensities at points remote from the hole or discontinuity. All these photoelastic stress patterns can be represented by a single mathematical expression of not too great complication, although somewhat cumbersome. Since the object of an investigation of this nature is to establish the effect of introducing a hole into a plate, under biaxial stress conditions, the corresponding chart of stress concentration factors is given in Fig. 3. This shows the ratio by which the peak stress is increased through the introduction of the hole. It is interesting to note that the presence of the round hole will at least double the stress, but the hole will never cause the stress to be greater than four times its value away from the discontinuity.

Photoelasticity has been applied to a wide variety of problems, ranging from railroad track to battleships, and has produced useful results where other methods of approach either proved inadequate or failed completely. From the point of view of the designing engineer and experimenter, it is of utmost importance to have an appreciation of the limitations of photoelasticity, since in spite of its power, it is by no means a "cure all". In consequence, its application should be definitely restricted to those problems for which it is properly suited.

Thirty years ago the cost of photoelastic equipment was prohibitive for all except the large industrial laboratories. Following the development of Polaroid, however, the cost of suitable apparatus has been greatly reduced so that now even small design offices and laboratories can afford this powerful tool for making analytical stress studies.

If apparatus is available it should see frequent and satisfactory application.

ENGINEERING ABSTRACTS

FOREIGN AND DOMESTIC ARTICLES

High Temperature Materials

Foreign Abstract Condensed from "Aspects of German Work on High Temperature Materials", in *Final Report No. 272* by British Intelligence Objectives Sub-Committee

IN LATE 1944 a conference of scientists and engineers took place in Berlin to discuss high-temperature material for jet aircraft engines. It was agreed that extensive research should be done on the use of ceramics for stator blades. It was decided to start work with the following materials:

1. Al_2O_3 + Fe, and materials such as "Ardostan", "Calit" developed by Hescho.
2. SiC+ other materials (carbon, Al_2O_3), for example SiC + C and Fe.
3. Quartz.

Work was also to be done on coating of metal blades.

It was considered that SiC would have a better thermal shock resistance than Al_2O_3 because it has a higher conductivity. It can also be mixed with other materials, including carbon, which has a low specific gravity. Since carbon is readily attacked by oxygen at high temperatures, it was thought that a protective coating would be necessary for this type of mixture. One objection was that a heating period of two weeks was necessary to sinter SiC properly.

Engineers at Hirth Motoren conducted tests on ceramic blades and under simulated service conditions found that cracks tended to form on the trailing edge. Blades with little difference in thickness between leading and trailing edges are better from this point of view, and a compromise had therefore to be reached between areodynamic considerations and resistance to cracking.

Several points were in favor of the use of quartz; it is easily welded and has a good resistance to thermal shock.

A certain degree of free movement had to be provided in the fixing of these blades to increase the damping capacity of the structure. Hollow air-cooled metal blades made from steel with a high nitrogen content (0.28 percent) were tried.

Richard Walther, an independent investigator, had worked for many years on carbides, high temperature metals and ceramics. He found that tantalum carbide was the most resistant to oxidation of all metallic materials. At temperatures as high as 2,000 deg. C. there was no appreciable oxidation. Beryllium carbide also was a very stable compound of metallic character. Walther believed that an alloy of tantalum and beryllium carbides could be developed as a super high-temperature material.

Walther developed an alloy with very good resistance to oxidation and good welding properties, having the following composition: 55 percent cobalt, 41-1/2 percent chromium, 3 to 5 percent silicon, 0.5 percent carbon. At high temperatures it forms a hard dense form of Cr_2O_3 and SiO_2 on the surface, similar to crystoballite. By replacing silicon with zirconium Walther thinks that the strength of material at high temperatures could be increased.

In the ceramic field Walther tested about a hundred different mixtures of oxide and found that the two best compositions were ZrO_2. Al_2O_3 + 5 percent Kaolin and BeO. Al_2O_3.

The Brinell hardness of these two materials is in the neighborhood of 800 kg. per sq. mm. The materials have a thermal shock resistance as great as quartz. Their strength at high temperatures is several times superior. Shrinkage during sintering was about 13 to 16 percent. The slip casting method of preparing the ceramics caused many failures in the first stage of drying as cracks occurred. Walther preferred a dry method and pressed them under 3,000 kg. per sq. cm.

Another experimenter, Dr. Schutte, developed materials for gas turbine use: For turbine blades—Tinidur; for combustion chambers an alloy known as B.V.T. 90 that consists of these percentages: 0.18 carbon, 0.935 silicon, 0.55 manganese, 1.43 chromium, 91.1 molybdenum, 0.55 vanadium. The alloy was chromised before use and gave satisfactory protection against scaling at temperatures ranging up to 650 deg. C.

Aluminum oxide blades were tested but the results were poor because of cracks. Porcelain gave encouraging results although the strength at 900 deg. C. was only that of alumina at 1,400 deg. C. Quartz assemblies gave unsatisfactory results because of the low strength of quartz at 1,000 deg. C. It is believed that quartz is a good bonding material for various mixtures of ceramics and carbides.

Hollow water-cooled blades for rotors were proposed and ceramics for stator blades, working at 1,100 deg. C. A method was developed for bonding alumina to steel by sintering a layer of iron powder between them. Meyer Hartwig was also working on a preparation of a rod of aluminum oxide and iron powder in such a way that the composition varies uniformly from 100 percent aluminum oxide at one end to 100 percent iron at the other.

Other experimenters worked on heater elements for 1,400 to 1,700 deg. C. temperatures. One type consists of a graphite rod concealed inside a gas-tight alumina tube with a mixture of alumina oxide and iron, provided with copper leads at the ends. The sealing mixture was graded from 100 percent alumina oxide at the joint with the tube to 100 percent iron at the joint with a copper connector. These were used in a horizontal furnace at a working temperature of 1,600 deg. C. and once heated, the furnace was never allowed to cool. After long heating some of these elements showed sagging.

Another heating element was made from a gas-tight sillimanite tube surrounding a molybdenum rod. The end of the tube was covered with copper caps. The rod was sealed to the tube with silver chloride and the entire tube water-cooled. It worked satisfactorily at 1,400 deg. C.

Nondestructive Testing

Foreign Abstract Condensed from "Nondestructive Testing of Materials Siemens-Werner Werk" in *Final Report No. 214* by British Intelligence Objectives Sub-Committee.

DURING THE WAR the German government offered a prize for the development of a method of testing metals for the faults represented by very flat bubbles of air in rolled metal. Such air bubbles are undetectable by X-rays or the magnetic powder method, unless the split comes very near the surface and is perpendicular to it. High current sometimes detect such flaws, but the method is not reliable. Dr. Pohlmann of Siemens developed a successful method using ultrasonics.

The transmitter was of conventional design using quartz at resonance frequency of 200,000 cycles per second.

The special feature of the instrument was the receiver. It consisted of a flat glass

jar, dimensions of 4 x 4 x 2 cm. This was filled with oil having fine aluminum powder held in suspension. The size of the particles was believed to be about the same as that used in aluminum paint. The oil was then illuminated from the side and when sound entered the jar, a pattern was clearly visible in the scintillating particles.

For contact with the metal a rubber sleeve was used. The ends of the rubber sleeve were closed off by the test metal and the receiver and the space in between was filled with mercury. Thus a mercury column transmitted the sound from one to the other. The equipment was so designed that when the flat piece of material was fed in by the operator, he had only to operate pedals. The test machine automatically attached both sender and receiver and also filled the rubber sleeve with mercury. The pattern was observed and if satisfactory, operating the foot controls caused the mercury to be drained while the sender and receiver were shifted to new areas on the metal and again the rubber was filled with mercury.

A modification of this method was used to test spot welds of sheet aluminum on aeroplanes. A clear transmission is shown in the receiver only if the weld has been soundly formed. Receivers for this application were made long enough to cover a row of spot welds.

Ultrasonic methods were also successfully used as an aid in soldering fine aluminum wire of the sort used in instruments. If electrical energy is used to burn up the oxide coating, a fine aluminum wire will melt. Therefore the surface must be very clean. The technique developed at Siemens called for passing 16 kc. sound through the wires, so that the friction between the wires kept oxides from forming. Solder was heated to 320-350 deg. C. and the wire was cleaned by simply dipping it in the solder, while a sound of 16 kc. frequency passed through the electric heater from below. If the wire was left in too long it gradually wore thinner from friction until it eventually vanished. The aluminum solder used is Alutinol V, composition 70 percent tin and 30 percent zinc.

Nondestructive testing with X-rays and with magnetic and high current methods were conducted at the Siemens plant, but did not differ materially from methods used in the United States.

Corrosion in Aluminum Bronze Alloys

Foreign abstract condensed from "Attack of Superheated Steam Atmospheres Upon Aluminum Bronze Alloys" by A. P. C. Hallowes and E. Voce in *Metallurgia* (England) July, 1946.

SEVERAL INSTANCES of the failure of aluminum bronze valve bodies and similar parts that operate in the presence of superheated steam have occurred. The failures were caused by corrosion of the aluminum bronze and often resulted in fracture, because of the reduced cross-section produced by the corrosive attack.

In attempting to determine the cause of the corrosive attack, aluminum bronzes containing 10, 11 and 12 percent aluminum and a 10 percent alloy containing 2.8 percent iron were subjected to the action of the steam of tap water at 400 deg. C. This steam was kept free of sulphur contamination. Even when contaminated with 1 percent air or with very dilute sulphuric acid (0.0001 normal) no evidences of corrosion were found.

When the steam was contaminated with slightly more than 0.1 percent sulphur dioxide definite attack occurred. Increases in the sulphur dioxide content, the temperature of the steam and the aluminum content of the bronze increased the rate of attack.

An investigation of the effects of steam containing sulphur dioxide on 90-10 and 88-10-2 tin bronzes indicated that the tin bronzes were relatively immune to attack.

Testing the Tooth Durability of Gears

From a paper "An Operating Test for the Evaluation of the Surface Durability of Gears", by T. H. Wickenden, G. R. Brophy and A. J. Miller. Presented at the 30th Annual Meeting of the American Gear Manufacturers Association, June 3-5, 1946.

TESTS AND TESTING EQUIPMENT for determining the surface durability of gear teeth are described and the results of a few tests are reported. The tests aim to find a relation between tooth stress and the number of repetitions of the stress and to establish that stress below which gears will operate indefinitely without failure of the tooth surfaces from pitting. Fig. 1 illustrates the kind of test data obtained, the curves having shapes characteristic of fatigue test results.

The test specimens were 28-tooth helical gears having a pitch diameter of 3.53 in. The pressure angle was 20 deg.; the helix angle, 7 1/2 deg.; and the face width, 1 in. The test machine operates on a modified "four-square" principle namely as though two pairs of identical gears were mounted angularly with respect to each other on either ends of two parallel shafts so as to cause an angular twist of the shafts that in turn sets up an applied load on the contacting teeth of all four gears.

This basic four-square principle had been modified in two ways: First, each shaft is interrupted with constant speed universal joints so that the gears on either end rotate, not in parallel planes, but in planes that would intersect at an angle of 75 deg. Furthermore the two interrupted shafts are so mounted that the mating gears of a pair rotate in planes at an angle of 15 deg. to each other. Second, the modified design provides trunnions in the mountings of one pair of gears so that

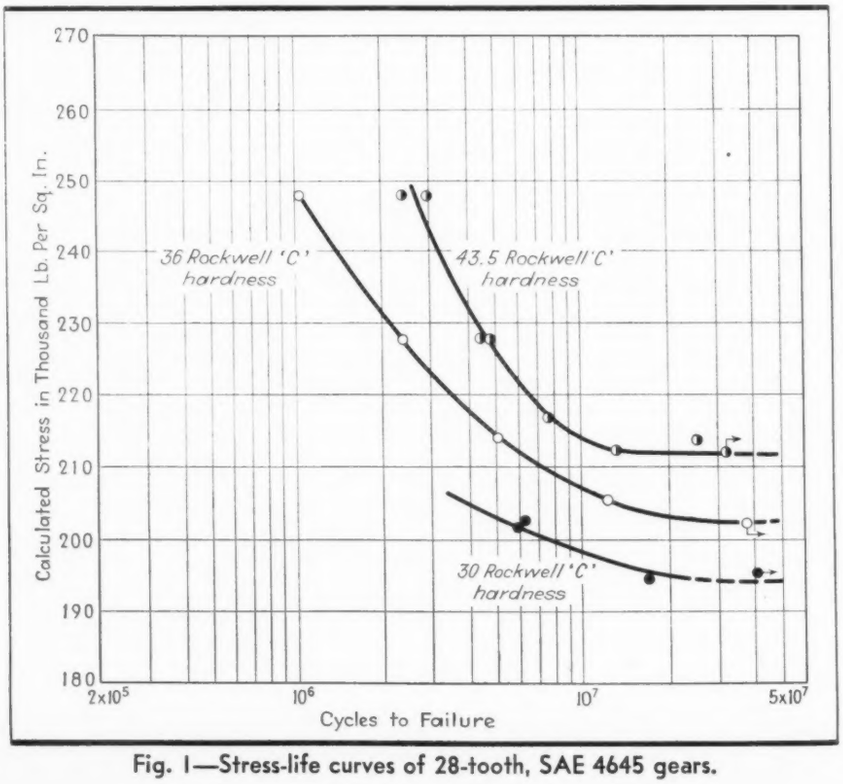


Fig. 1—Stress-life curves of 28-tooth, SAE 4645 gears.

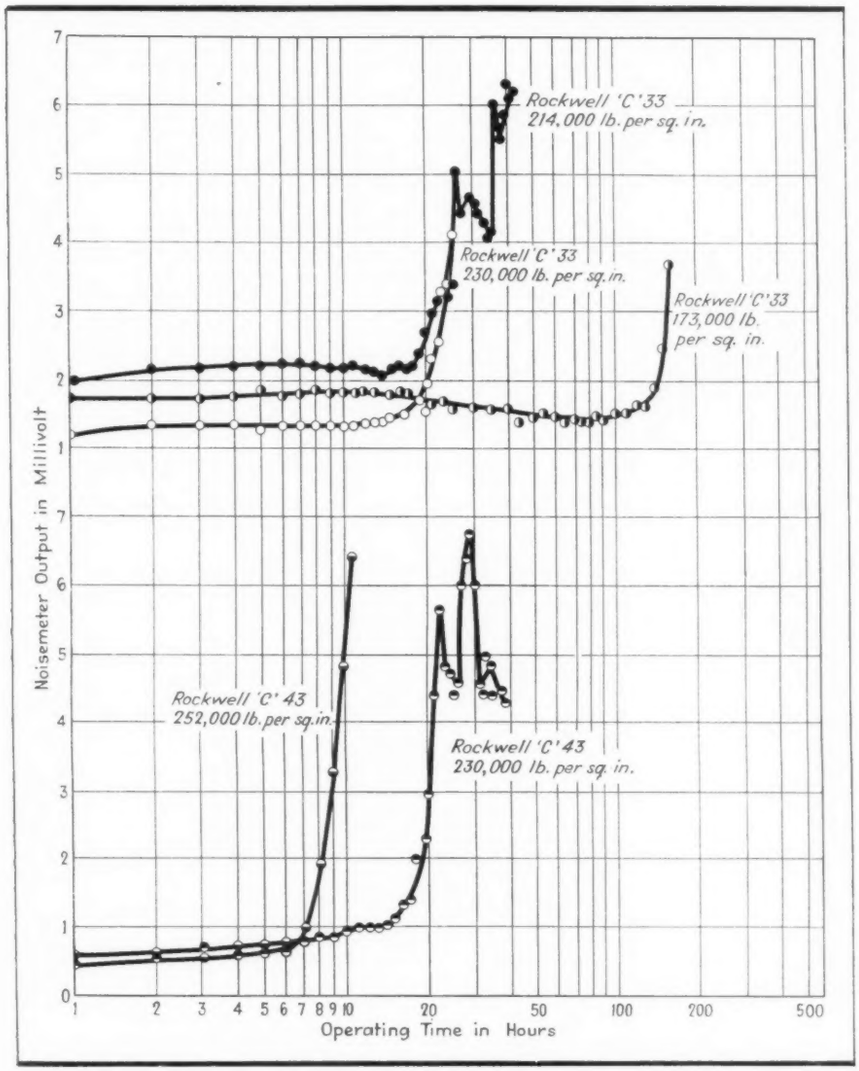


Fig. 2—Some typical gear test noise records.

a torque can be applied to the system merely by placing weights in a pan hung from a torque arm.

Since the mating gears rotate in different planes, full width of contact is not possible. Actually, contact occurs over an elongated elliptical area, which is more or less restricted to the central portions of the teeth. Localizing the area of contact in this manner has the advantage that the test stresses can be induced in the teeth to the desired maximum without approaching the beam strength limit of the teeth. The upper limit of stress is nearly 250,000 lb. per sq. in. for these 28-tooth test gears.

Stresses that cause pitting of gears must not be simple tension, for they originate from two sources: (1) The tension component of the operating compressive stress, and (2) the tangential tensions in the tooth surfaces developed by the action of the teeth during operation. The second is believed to be of greater importance because of the conditions peculiar to the test. Since the test gears rotate in different planes, each tooth slides endwise over its mate. The first sign of tooth distress during a test is a scoring action that causes a series of arrowhead markings with apexes on the pitch line and pointing in the direction of sliding. This frictional force must develop a high degree of tangential tensile stress in the tooth surface. The stress is evidently more severe in the driving teeth, for they always pit first and more extensively.

Microscopical examination of incipiently failed gears indicate that the first stage in pitting failures is the formation of fatigue cracks normal to the tooth surface as well as to the direction of the surface forces. Subsequently, a particle of metal is sheared out from this crack in the direction of the force to form a pit, which in a driving gear is away from the pitch line and in a driven gear toward it. Once started the spread of pitting is rapid and destructive.

The noise emitted increases continuously with the spread of pitting. This suggested that a noise meter might yield a dependable indication of destructive pitting. Accordingly, a simple and inexpensive device was assembled that measures the noise level in terms of millivolts. Fig. 2 shows some noise level records. The initial millivolt reading of any test has no significance because that could be varied at will and was adjusted in order to space the records. The significant thing is that failure or destructive pitting of the tooth surfaces is marked by a continuous rise of noise level.

Fatigue Strength of Wood

From "Fatigue of Wood and Glued Wood Constructions", by W. C. Lewis, Forest Products Laboratory, United States Department of Agriculture. Presented June 25, 1946, at the annual meeting of the American Society for Testing Materials.

SUITABLE SPECIMENS and methods have been developed at the Forest Products Laboratory for testing wood or plywood in cantilever bending in flat plate machines and for making tension-parallel-to-grain, tension-perpendicular-to-grain, or shear-of-glue-line tests in direct stress machines. Experience has shown that, with proper monitoring schedules, essentially constant repeated loads may be had for the duration of the tests in the direct stress fatigue machines.

The design of specimens is complicated by the characteristics of the material. Large radii of curvature are required in transition sections of tension or bending specimens to avoid early shear failures. Methods of mounting specimens in the testing machines have been developed. It has been found desirable to avoid the use of wedge grips, or bolted connections. This was accomplished by gluing steel plates to the wood specimens.

The results have indicated that the endurance limit (the maximum stress that can be repeated indefinitely without failure) of wood and glued wood constructions is not found in tests up to 50 million cycles in cantilever bending, or up to 30 million cycles in direct stress. The S-N curves tend to become asymptotic to a horizontal line but the curve is still a decreasing function at these limits. Consequently, fatigue test results are discussed in terms of endurance loads for a specified number of cycles. Results of tests on wood and plywood flat-plate bending specimens have shown that the endurance load for 50 million cycles is about 27 percent of the static modulus of rupture when stresses are reversed (mean stress zero) and approximately 35 to 40 percent when stresses are repeated (minimum stress equal to zero). Tests have also shown that 5,000 repetitions of bending stress to as high as 85 percent of the static modulus of rupture do not reduce the subsequent strength of five-ply Sitka spruce plywood under flexure in the same direction as the repeated loads, but similar repetitions greater than 30 to 40 percent lower the final strengths under loading in the opposite direction.

The results of direct stress tests in tension parallel-to-the-grain (ratio or mimimum loads 0.10) indicate that the endurance load for 10 million cycles is about 50 percent of the static strengths for both

solid and glued scarf-jointed specimens of Douglas fir. Similar tests on Douglas fir glued laminated specimens with the glue lines stressed in shear indicate the endurance load for 30 million cycles as approximately 45 percent of the static strength.

In all tests the failures of wood and glued wood construction in fatigue were exactly the same in appearance as failures from static loading.

Die-Cast High Melting Point Alloys

Foreign abstract condensed from "High Melting Point Alloys" in *Mechanical World and Engineering Record*, England, July 26, 1946.

THE ART of die casting magnesium, brass and other copper alloys has advanced tremendously during the past few years. The major reason for these advances has been the replacement of the hot-chamber casting machine by the cold-chamber type. Cold-chamber die casting, in which the metal is injected into the mold at high speeds and under high pressures, produces a casting of finer detail and with better physical properties, because of greater density and better control of the composition of the metal being injected.

Plain carbon steel dies have been used successfully for the production of small quantities of magnesium die castings. However, when reasonably large quantities are required, a hot die steel of the 3 percent chromium, 3 percent tungsten, 3 percent vanadium type will be more satisfactory, because of its longer life.

In the production of brass or other copper base alloy die castings, the die steel should be of the red-hard high tungsten type such as 18-4-1 high speed steel. Although this steel is difficult to machine, it can be depended upon to give a life of 20,000 to 60,000 cycles when heat-treated to approximately 500 Brinell. In general, the maximum size of castings and the life expectancy of the dies decrease as the melting point of the alloy increases.

Although threads can be successfully cast in the copper base alloys, the life of the thread inserts of the dies is short. It is usually best to machine any necessary threads as a separate operation.

D.C. Motor Speed Regulation

Foreign Abstract from "D.C. Motor Speed by Vibrating Relays," V.D.I.-Zeitschrift, Sept. 16, 1944, page 510.

A NEW speed regulating system for small, lightly loaded d.c. motors with a low internal resistance and for continuous operation at 0.5 to 1 kw. has been developed. The system, shown in Fig. 1, affords steady regulation of motor speeds and produces good starting torque at all of these speeds. When the mechanical load on the motor changes, the motor current changes simultaneously and in direct proportion to the change in load. Actually only a negligible change in motor speed is necessary to start the system in operation. For each position of the controller there is a corresponding motor speed. The motor will run smoothly, even at its lowest speeds where the frictional moment is subject to rapid changes.

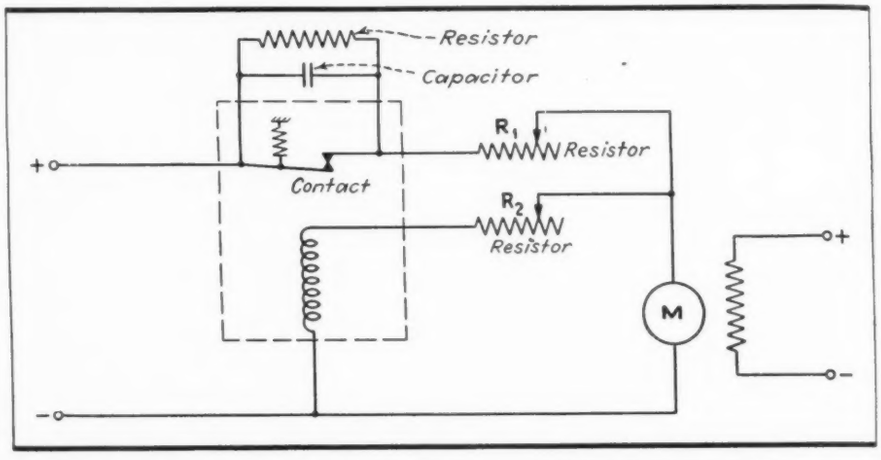


Fig. 1—Schematic of vibrating relay for controlling motor regulation.

The system (developed by Grau; see D.R.P. 345, 267, Nov. 18, 1919) functions in the following manner. When the service switch is closed, current flow is established at the motor, which then starts and endeavors to attain a high speed. The relay remains closed, until the commutator voltage reaches a certain value at a speed that is determined by the setting of the resistance R_2. When this speed is exceeded, the relay opens and interrupts the flow of current. When the contacts are open the motor functions as a generator that feeds current to the exciting magnet of the relay. However the voltage of this current flow is less than the starting voltage of the relay. For this reason the relay closes and re-establishes the current, followed by the re-opening of the contact. This cycle now repeats itself about 30 times per second in rapid succession. The vibration of the relay weakens the motor current flow sufficiently to stabilize the motor at its normal speed.

By adjusting the resistance R_2 any desired motor speed within its range can be established. This regulation is independent from the motor load that is compensated by the magnetizing current. During the load changes the ratio between opening and closing time of the relay adjusts itself.

Printing and Wrapping Machinery

Foreign abstract from "Combined Printing and Wrapping Machinery" by J. A. Cuckson, in *Mechanical World and Engineering Record*, July 12, 1946, page 29.

HIGH SPEED MACHINES form, mold, cut and wrap candy at a rate of 700 pieces per minute, using preprinted wrappers from reels. Many manufacturers desire that the printed design of the wrapper be placed on the top surface or two sides or all three sides simultaneously so that the reading matter is always legible. This is arranged by having holes punched in the paper at regular intervals and at a specified distance from the cut-off position. The feeding of the wrapper is controlled mechanically by a peg intermittently entering the punched hole and drawing off the desired length. Photoelectric cells, working from an opaque mark on the wrapper, are also used but only for slow running equipment.

A considerable saving is effected by fitting an automatic printing device upon the wrapping machine. By this method the wrapper design can be easily altered, printed in perfect register, and valuable floor space saved.

The wrapping material is carried in reel form and is threaded over rollers to pass through one or more printing devices. When the highly volatile liquid gravure inks have been applied and come into contact with natural air, electrically heated rollers, or pass through an air blast, they are completely dried. The web is then fed directly into the wrapping machine with no fear of blurring or of another color being superimposed. In the rotogravure method of printing, the design is etched in the cylinder periphery, and by using a rubber pressure roller for printing, the intensity of pressure applied is uniform irrespective of the design. Registration of the printed panel can be achieved by devices working from a punched or notched perforation.

The Weiss Speedy totally-inclosed ink reservoir is designed to guard the product against contamination by foreign matter. It is made airtight to prevent dusting powder from entering the container and

to arrest the evaporation of the inks.

A diagrammatic view of the ink container is given in Fig. 1. As the whole of the inking unit A is airtight, the ink must be pumped into it. The ink is passed through the ink spray arm *B*. The reservoir is continually agitated. A series of minute cup-like indentions on the etching of the roller C are used to carry the ink applied by spray arm *B*. At this stage the entire roller surface is covered. A finely adjusted pivoted scraper blade *D* is so set that all ink lying on the smooth surface of the roller C is returned to the ink container. As the unprinted surface of the web passes over the etched roller *C*, the rubber pressure roller *D* presses into the recesses where the ink in the design is picked up on the under surface of the web. The printed web can be passed to another printing unit for an additional color or design or be fed directly to the rollers of the wrapping machine. Foil, glassine, Cellophane and photofilm can be printed by this device.

In many instances the automatic cutting and wrapping machine is used to wrap goods of varying sizes and shapes. This can be easily done as regards the printing of the web by interchanging the gravure printing rollers.

The sequence of wrapping operation is shown in Fig. 2. The caramel is brought to the machine while still warm and in a plastic state. Before entering the wrapping machine it is pulled either by hand or mechanically until it is rope-like in appearance and has a diameter of approximately one inch. It is then fed between the sizing rollers A that mold it to its correct width and thickness. These rollers are geared to feed sufficient caramel to form one piece at a time. At the proper moment a rotary cutting knife *B* severs the measured length.

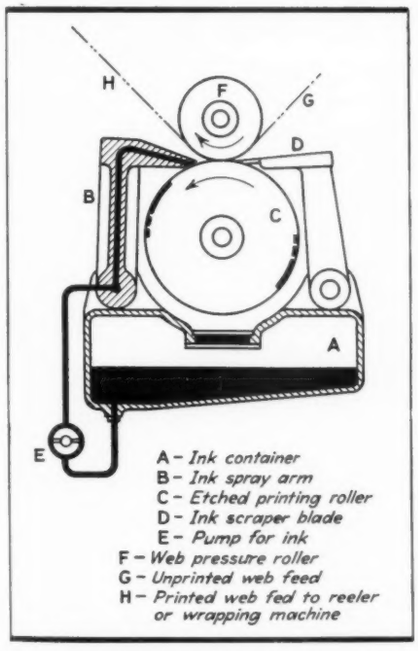


Fig. 1—Schematic drawing of patented printing device.

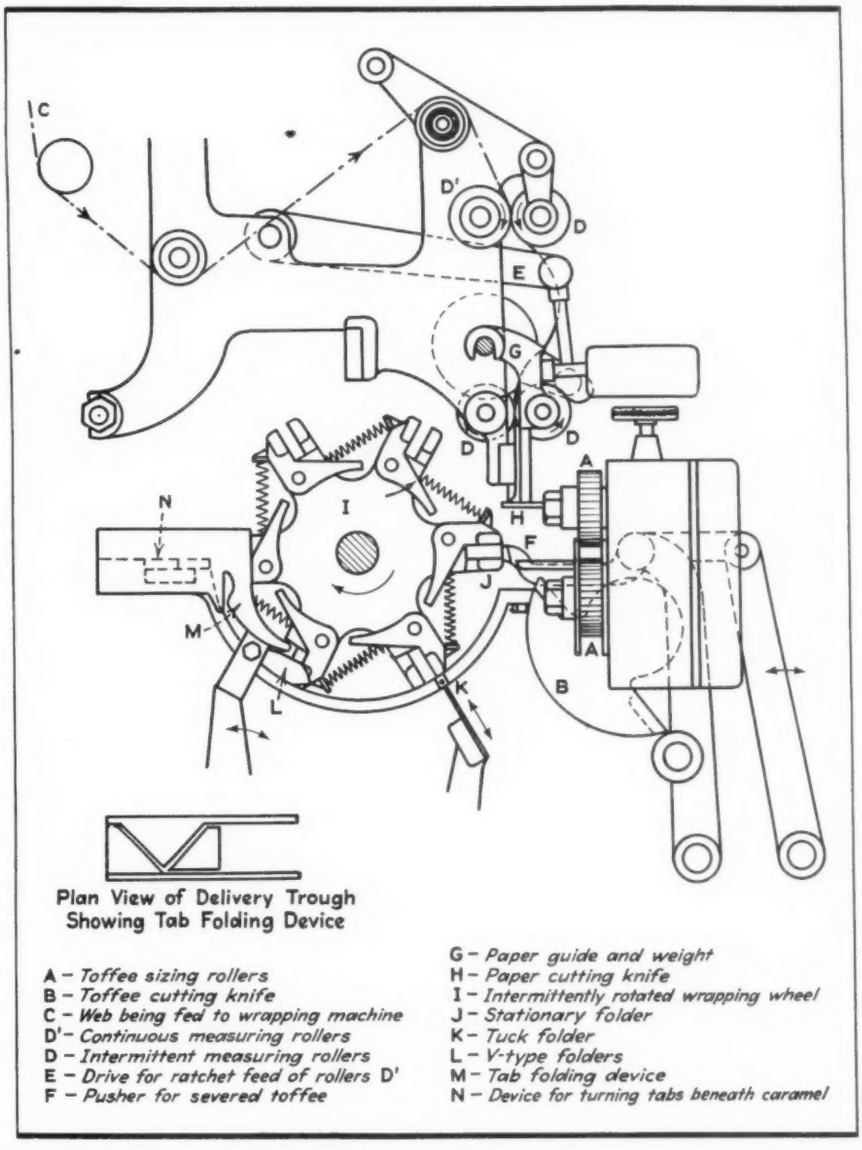


Fig. 2—Schematic drawing of combined printing and wrapped machine, showing wrapper feed and wrapping mechanism.

Prior to this, the unprinted web *C* has been fed from its reel, the design printed on it, and the web fed by measuring rollers *D* to a position in front of the pusher *F*. The pusher moves forward carrying the severed caramel and strikes the paper which has been cut off by the paper cutting device *H*. Together the candy and wrapper are thrust into an empty pocket of the wrapping wheel *I*. This places the wrapper around three sides of the candy. A Geneva wheel, to which the wrapping wheel is secured, moves downwards causing the projecting length of the wrapper to stroke the stationary folder *J*. As the wrapping wheel comes to rest, the tuck folder *K* pushes the upturned piece of paper into contact with the face of the caramel. The wrapping wheel is indexed again and the folders *L* impinge upon the protruding rubber which is on both sides of the wrapping wheel. The folders swing inwards and make the end fold in the shape of triangular tabs. The wrapping wheel is again set in motion and on its upward travel carries the triangular folds into stationary folding fingers *M*, which lay the folds upon the ends of the caramel.

After the wrapping wheel comes to rest, the partially wrapped candy is ejected from the wheel into a delivery trough. The triangular tabs pass through more stationary folders *N* that fold each of the tabs in succession upon the bottom of the caramel. This completes the package and upon its passage through the discharge chute it passes over a heated surface. This liberates the adhesive of the wrapper so that subsequent passage over a cooling plate securely seals the tabs. Production on this type of machine is approximately 600 pieces a minute.

INDUSTRY AND SOCIETIES

RESEARCH—STANDARDS—PATENTS

The Cavity Magnetron

Microwave Producer, Heart of Radar Looks to Industrial Applications

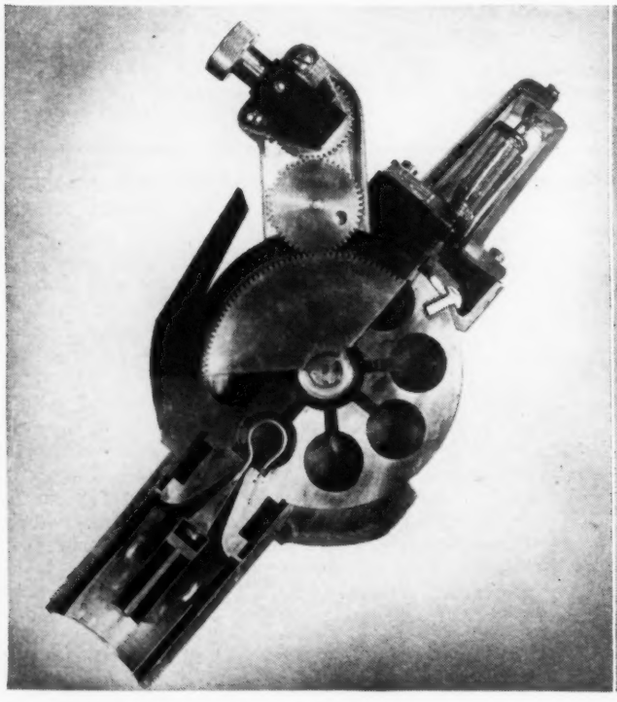
THE CAVITY MAGNETRON is the most important electronic tube to be developed in the last decade. From its original use as a microwave producer in radar sets it has initiated a whole new level of basic research in super high frequency microwave transmission. It has brought into play completely new thinking in the electronic field.

Up until a few years ago, comparatively low frequencies were considered the practical limit by engineers. Broadcasting stations for example transmitted over a band of frequencies, the center of which was one megacycle. Ultra-high frequency was spoken of as 60 to 100 megacycles. By the end of the war, however, many radars employed cavity magnetrons capable of generating pulses of radio energy in the order of 10,000 megacycles. Wave lengths in broadcasting stations operating on one megacycle are in the order of 300 meters. In comparison, wave lengths of some of the latest magnetrons are three centimeters and less. Output power for regular broadcast radio stations range up to 50 kilowatts, while some cavity magnetrons develop instantaneous (peak) powers of up to 1500 kilowatts. The tendency is apparent: The scientist is making radio waves approach the wave length of light; this means that he must learn to exercise greater control of the electron itself.

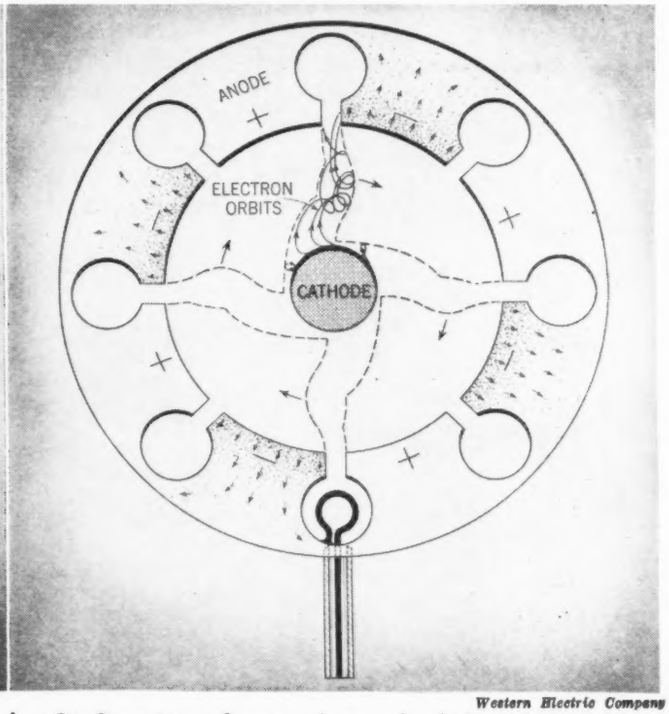
The cavity magnetron is a two element electron tube. Its electron source is a cylindrical unipotential heater cathode called an oxide coating which is supported in the center of a massive copper anode. Each anode as shown in the accompanying diagram contains a number of resonant cavities shaped in cross-section like keyholes with stems or slots feeding into the central cathode chamber, all of which comprise the tube's high frequency circuit. The tube is equipped with a base of nonmagnetic material which supports the tube so that it is symmetrically located between the poles of an electromagnet.

Operation

Here is how the magnetron operates: A high voltage applied to the cathode boils out free electrons, which are attracted to the surrounding positively charged anode. The electrons, instead of flying straight



The 4J51 tunable cavity magnetron represents a marked advance in microwave vacuum tube design.



Western Electric Company

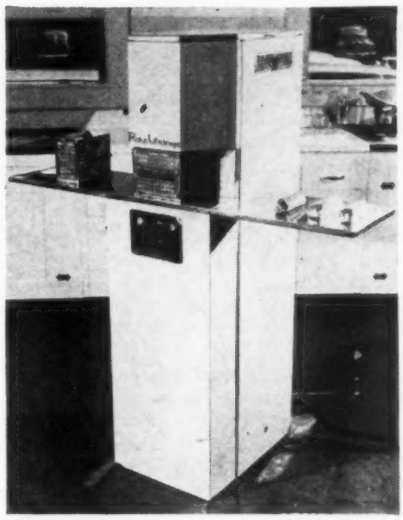
Configuration of space charge clouds in a cavity magnetron. Spiriling lines represent electron paths.

from cathode to anode are curved by the right angle force of the magnetic field. They are bunched into clouds shaped like spokes of a pinwheel. Its wheel sweeps around several billion times a second. As the cloud of electrons makes its sweep, it repells free electrons in the middle between the cavities, making the middle intersteicies alternately positive and negative. This rapid alternation around the cavities produces oscillating electromagnetic field across slots.

It should be noted from the diagram that one wall of the slot is always positive when the other is negative, and also that the potential between the walls of any one slot is the reverse for the two adjacent slots. However, when the tube is in operation there is a continuous change in the potential between the walls of each slot.

Thus, when an electron emitted by the cathode starts on its course to the anode, it is first affected by the applied magnetic field and begins to bend. Some electrons are driven back and bombard the cathode, while others proceed on a curved path of cycloidal form. If, on this journey, the electron approaches a region of negative potential, it will be slowed down or repelled, while other electrons following in its wake, because of the rotational velocity, will approach a region of positive potential where they will be speeded up and catch up with the electrons in front. Thus, the electrons collect in bunches and form, in effect, a pinwheel.

The same electrical fields inside the cavities oscillate at high frequency determined by size and shape of the cavities. Smaller cavities produce higher frequency power generated within the cavities is by a coil in which coaxial cables are led directly into the wave guide on up to the antenna. Tapping one cavity taps them all. By pulsing the power to the magnetron, a thousand times a second or more, bursts of high power microwaves are sent from an antenna in a narrow radar beam.



Raytheon Photo

Practical application of a magnetron is the "Radarange", demonstrated recently by the Raytheon Manufacturing Co. It uses high frequency energy, directed by a waveguide, to grill a hamburger sandwich in 35 seconds, bake a cake in 29 seconds. Now used to heat frozen foods.

Future Uses

Considerable speculation is already under way as to the possible future uses of a cavity magnetron. Some are sound and others verge on the border of fantasy. One certain use will of course be in the peacetime applications of radar. Other possible uses are in multiple transmission of messages and in such domestic applications as shown in the accompanying photograph—the heating and cooking of food. At present, however, its greatest use is in basic research.

Fatigue Failure of Steel Predicted by New Method

A METHOD FOR PREDICTING from its stress history how long a metal will last under a vibrating load, or how much load it will stand when subjected to vibration, has been developed by John A. Bennett, of the Bureau of Standard's Metallurgy Division. Although this investigation was limited to one metal only, X4130 aircraft steel, the possibility of using the method for predicting failure of other types of metals is being investigated.

Vibration is a prime consideration in the design of aircraft members, automotive parts, machine elements, and other metallic objects that are subject to its damaging effects.

Fatigue in metals has been extensively studied, and it has been found that for most ferrous metals there exists a stress range within which a pulsating stress will not cause failure, regardless of how many cycles of stress are applied. If this range, which is known as the fatigue limit, is exceeded, a crack will eventually form and will grow until fracture occurs. Prior to the formation of the first crack there is a change taking place in the metal that reduces the fatigue properties, but does not affect the other mechanical properties.

A study of some of the phenomena associated with this damaging process, particularly with a view to making the information more readily applicable in the design of structures, is reported in the Bureau of Standards Journal of Research for August. Fatigue damage to a specimen at a given stress was measured by the decrease of endurance observed at another stress. Two methods are described to determine by extrapolation the point at which cracking starts. A method of expressing damage independent of stress was also developed, which permits the direct addition of damage occurring at different stresses.

Previous studies of fatigue damage have dealt largely with smooth specimens although the majority of fatigue failures in service propagate from points of stress concentration. Therefore, the first part of the work consisted of an investigation of fatigue damage using notched specimens. The results, which were similar to those obtained with smooth specimens, show that the apparent rate of damage is a complicated function of the stress history. Tests to determine the cumulative damage caused by fatigue at more than one stress were also made with smooth specimens.

Army-Navy Drawing Practice Standardized

THE JOINT ARMY-NAVY COMMITTEE on Standard Drawing Practices is nearing completion on four sections of its work, and individual standards will be issued for compliance of the Services and manufacturers to specifications for production of arms and equipment. These four sections, in charge of task committees are: (1) Abbreviations, (2) welding symbols, (3) drawing sizes, and (4) screw threads. In all there are now 24 drawing practice tasks on the agenda, for some of which committees have not yet been appointed. The agenda will be increased from time to time.

The Committee on Standard Drawing Practices was set up late in 1944 as a result of a joint memorandum from Secretaries of War and Navy to the Army-Navy Joint Specifications Board, which functions under the Army-Navy Munitions Board. The Specifications Board is headed by an Army and a Navy official, acting for six months each alternately. The same two officers preside jointly over the Drawing Committee.

Near the war's end several large manufacturers told the Army and Navy that differences in drafting practices and specifications had cost long delays and huge waste of manpower and money, and that such differences might be more serious in any future war. The American Standards Association took an important part in formation of the present drawing program, but has since dropped out of the picture, apparently because coordination of both industry and military drawing standards at the same time was too complicated.

The 24 task committees of the Drawing Practices Committee include the following:

General drawing practices: Projection, sections and sectioning, scales, lettering and line conventions.

Drawing sizes: The committee has reduced total sizes from about 55 to 11; most of the new sizes are in multiples of 8½" by 11" letter size. A few special sizes are set up for aircraft and other products.

Drawing numbers and parts numbers: This probably will involve gearing for business machines. Most manufacturers want to limit numbers to 10 places, saving space for other designations. Some manufacturers are running out of numbers, due to war production.

Surface roughness: Standards will be thoroughly coordinated with industry.

Materials: Because of data that will go

into this section, further study is necessary before scope of the standard can be set up.

Welding symbols: Will be thoroughly coordinated with American Welding Society and there will be no technical differences between the two.

German-Owned Patents To Be Available

MORE THAN 100,000 patents for everything from aeronautics to woodworking will become available as a result of a recent agreement on German-owned patents reached by a twelve-nation conference in London, the State Department reports.

Countries represented at the conference were Australia, Belgium, Canada, Czechoslovakia, Denmark, France, Luxembourg, Netherlands, Norway, Union of South Africa, United Kingdom, and United States. Formerly German-owned patents coming under the control of any one country as a result of war-time operations are to be freely available to nationals of the other governments subject to the protection of any existing contracts.

19,000 of the German patents seized by the United States are now licensable under the agreement. The Office of Alien Property Custodian which has licensed approximately eight thousand seized German patents to American citizens during the last four years will continue to protect all lawfully acquired exclusive licenses.

Information on enemy patents vested in the Alien Property Custodian may be obtained from Office of the Alien Property Custodian, Washington 25, D. C.

* * *

A wealth of technical information has been made available to Southeastern industry through the establishment at the Library of the Georgia School of Technology, Atlanta, Ga., by the Alien Property Custodian of a complete file of enemy patents seized by the Government during the war. Thousands of ideas for new materials, new processes and new products are contained in these patents which may be utilized by United States citizens on a non-exclusive royalty-free basis under reasonable licensing fees.

The abstracts cover mechanical-electrical patents and chemical patents in the first part of the 4,450 pages covering some 37,000 patents and consists of such topics as bleaching and dyeing, motor vehicles, machinery, paper manufacture, plastics, radiant energy and textiles. The second part of 34 volumes comprises approximately 7,000 chemical patents grouped by fields of interest, including ceramic materials, foods, fuels, textiles, pulpwood and paints.

New Tester Aids Crankcase Design

NEW TEST EQUIPMENT which will eliminate much of the guesswork in crankcase ventilation research and engineering has been announced by the Ford Motor Company. The new equipment makes possible an accurate measurement of the effectiveness of crankcase ventilation systems at all speeds and under all conditions, showing by direct reading the actual amount of air passing through the crankcase at any instant.

Automotive engineers have been working for several years for an effective method of ventilating the crankcase, pulling out gases which lead to formation of sludge. Several methods have been developed, but the effectiveness always has been questionable because there was no accurate means of measuring exactly how much air was being circulated at various engine speeds.

The new device makes use of two air flow measuring tubes, one showing flow of air into the engine, the other showing the flow of gases out, giving direct readings of the effectiveness of the system employed. Small blowers are used to compensate for line drop. The equipment is portable and may be mounted in a few minutes.

French Auto Exhibit Reveals New Designs

REFLECTING POSTWAR ECONOMIC CONDITIONS, the world's first automobile show since the cessation of hostilities was held in Paris on October 3, 1946. The limitations of materials and labor imposed on French manufacturers have resulted in some clever solutions to difficult design problems. Added to these difficulties are the high cost of gasoline and the shortage of steel. Generally speaking, the solution to these problems has taken the form of developing small light cars.

Reduction of weight has not only been accomplished by reduction in size. Application of aluminum and magnesium has been extensive. Other weight reduction methods include moving the engine and transmission together. More compact chassis design has been accomplished by independent wheel suspension combined with the use of coil springs.

Several models were particularly interesting from the design viewpoint. One of these was the three-wheeled Mathis 33. Its overall length is 11 ft. and it is claimed o obtain 66 miles per gallon on an average of 44 miles per hour. A one-piece body frame welded from sheets of aluminum alloy reinforced with horizontal members, replaces the conventional chassis. Another interesting car is the all-aluminum Gregoire model.

A more standard car is the 1,140 lb. Renault. Rear motor, 4 passenger, 4 wheeled, 4 door sedan, the Renault has the same type of welded single piece caisson body as the Mathis. As in all the new French cars, the main mechanical weight rests near the driving wheels, to give better traction. The normal engine space is occupied by a baggage compartment and spaced for the extra tire. An aluminum car, which might appeal to the American demand for roominess, is the six passenger Claveau. This sedan has an 85 hp. v-8 engine, is 16.4 ft. long and gives 22 miles per gal., fully loaded at 63 miles per hour. This car will have a front engine drive.

Reaching new extremes in lightness, the Irat has been developed in cooperation with the French Magnesium Society. As shown in the accompanying photograph, this is a 3-place coupe having a 90 in. wheel base and a weight of 1,050 lb. Its advanced body styling enables the 40 hp. motor to drive this model at 75 miles per hour, at 4000 rpm; average gas consumption is expected to be 35 miles per gallon.

WASHINGTON NOTES

Presidential Research Board Reopens Science Issues

Establishment of the Presidential Research Board by President Truman for the purpose of coordinating federal activities in the field of science, has reopened all the issues that centered around the controversial science bills. It is believed by some that the new board was set up as an administrative substitute for the National Science Foundation, which was blocked in the closing days of the last Congress. The issues involved in Federal science legislation have been covered in the "Washington Notes" columns of the past year. It will be recalled that both scientists and politicians split up into two camps on these bills. One side headed by Senator Harley M. Kilgore of West Virginia and including such scientists as Dr. Harold Urey, favored the Kilgore-Magnuson legislation that would have centralized all federal science activities. The other side, apparently not so well organized as the Kilgore camp, but including such established scientific leaders as Dr. Isaiah Bowman of Johns Hopkins University, favored some sort of legislation that would provide for federal support of research, but did not want this legislation to furnish a wedge for federal control of their scientific activities. These people had supported a bill sponsored by Rep. Mills, which was also killed in the last Congressional session.

Enter, Steelman—By naming reconversion Director John R. Steelman to head the new group, the President signified his awareness of the lack of any coordinated federal science legislation. The direction of his thoughts can be seen from the statement that he issued as to the purpose of the new board: "To insure that the scientific personnel, training and research facilities of the nation are used more effectively in the national interest." Another purpose of the Board would be to prevent overlapping among various federal agencies on research work. The clear implication of the statement, however, was one of national security. This was brought out by the naming of the membership of the Board to include, in addition to Mr. Steelman, the Secretaries of Agriculture, Commerce, Interior, Navy and War; the Federal Loan and Federal Security administrators, the chairman of the Federal Communications Commission, Tennessee Valley Authority, and the National Advisory Committee for Aeronautics, and the director of the Office of Scientific Research and Development.

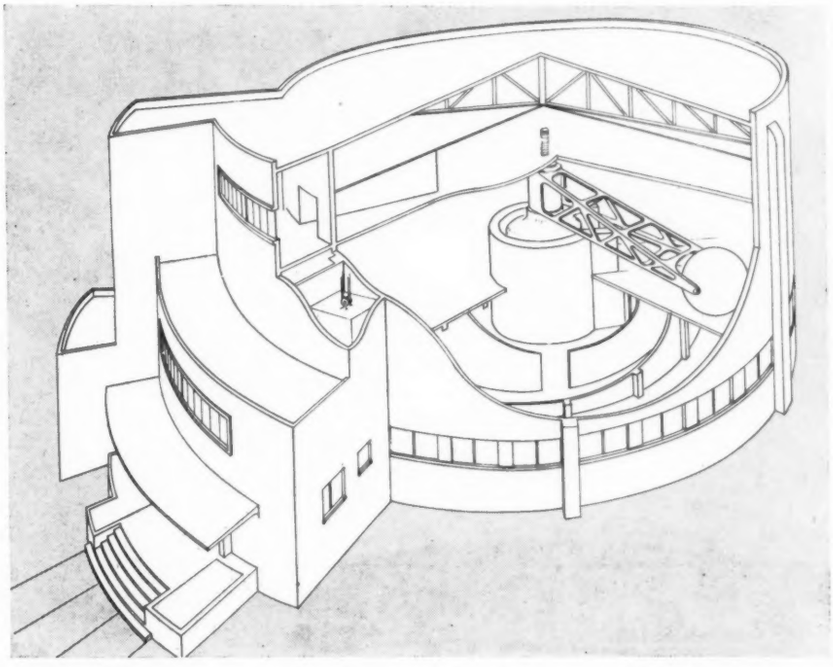
Civilian vs. Military?—Appointment of the new Board also reflected the growing distributions among civilian agencies in Washington over the quiet tendency towards militarization of the government. This trend is especially evident in the field of science since almost all manpower available for basic research seems to be working under military direction, either directly or indirectly.

There is a feeling in some quarters, therefore, that although the new Board has been set up as an interim substitute for a national science foundation, it actually represents an effort on the part of the civilian agencies to apply the brakes to growing military control of scientific research. One of the avowed purposes of the new Board is to study all federal research with a view to listing what percentage of this research is Army, Navy, Manhattan District and civilian programs. It will also report on whether these research activities are diverting national effort from the main lines of industrial development.

Patents—There is a wide discrepancy in government circles as to whom patents and other results of publicly financed research should belong. The Justice Dept. believes that these results should be treated as the property of the investigator, no matter for whom the work is done. This also has been the practice of the military agencies. Some Congressmen, however, disagree with this view and believe that all results of such research should be made generally available. In any event, the belief is widespread that the new Board is merely window dressing for Steelman's investigation.

The Military Side—It is certainly no secret that both sides of the military vs. civilian controversy are girding themselves for a battle in Washington. It is quite likely that Steelman's report may be followed by the formation of an executive agency to oversee government work in science. Another phenomenon that will probably enter into the picture is industry's growing faith in the ability of the military services to handle the basic research job quite adequately. The basis for this belief has grown out of pure experience and not from any theoretical considerations.

In the absence of Congressional accord on a civilian program for science, military services have taken over the job—Navy about a year ago and the Army more recently. Just before the end of the war the Navy tackled this problem by setting up the Office of Research and Inventions. This year permanent legislation for the agency was enacted, and it was reorganized several months ago as the Office of Naval Research under Vice Admiral H. G. Bowen. The Office of Naval Research



Study Supersonic Speed in Human Centrifuge

The Navy has completed plans to construct the world's largest human centrifuge—to be used in studying man's reactions to forces developed in flight at supersonic speeds. A building to house the centrifuge to be erected at the Naval Aircraft Modification Unit, Johnsville, Pa., by the Navy Bureau of Yards and Docks. The centrifuge, described by the Navy as the "only one in the country capable of simulating flight conditions," will resemble in principle an amusement park "airplane." Low pressure chamber will permit it to simulate altitude pressures of 60,000 feet. Instruments to record chart reactions, and laboratories to evaluate them, are included in the construction plans. X-ray cameras, capable of taking a series of 12 to 14 pictures a second, are under development for the device. They will be installed in the cab for study of the effects of acceleration on the subject's internal organs.

steers clear of developing the specific naval equipment, which is the job of the Bureaus of Ordnance, Ships, and Aeronautics. Its task is to stimulate and guide fundamental research. It does some of its work in the Naval Research Laboratory in Washington but the majority of it is done through loosely-negotiated contracts with civilian colleges. For the coming year, ONR has $45,000,000 of which about $11,000,000 will be spent for basic work in industrial laboratories, and about $26,000,000 at universities. These contracts are financed on a nonprofit basis. Sometimes ONR arranges for investigation of a particular subject but ordinarily the college or research group works up a program of an investigation it would like to pursue and offers it to the Navy. If ONR can see some possibility of ultimate results having military value, and if it thinks the institution is competent it will contract to start the program.

Admiral Bowen's group is an enlightened one. Realizing that original research cannot be requested, it is consciously trying to maintain a civilian "feel" and to operate in much the same way that a national science foundation would. In approving projects, however, they must look for a military application even though it is remote. Of the first year's contracts, about 40 percent were nuclear studies, 14 percent were devoted to electronics, while medicine and fundamental research of problems in guided missiles each accounted for over 10 percent. The rest were scattered among chemistry, geophysics, mathematics, and various branches of physics.

Although the Army has been slower than the Navy in getting into the basic research, it is moving into the field in a big way. The Army research budget this year is about $280,000,000 of which about $70,000,000 is headed for fundamental study at universities. The remainder will be spent on development work at Army centers and through industrial development contracts.

The Army has no central operating organization for scientific research, similar to the Navy's Office of Naval Research. The contracts are let through individual Army Branches. A new trend is evidenced, however, in a new division of the Army General Staff, G-6, headed by Major General H. S. Aurand. Its assignment is to coordinate Army research. Aurand is noted for his backing of close collaboration between the military and civilian scientists and engineers at the level of strategic planning.

Since the list of high-priority Army research projects practically duplicates the Navy's program, a Joint Research and Development Board to coordinate these programs has just been mechanized. The Board consists of four high ranking officers with Dr. Vannevar Bush as civilian chairman. The Board's initial approach will probably not be the allocation of subject matter between the services but will center its activities on allocation of institutions and personnel—permitting the Army to

Automatic Altimeter Increases Air Safety

A REMOTE CONTROL radio device to aid air traffic control and instrument flying efficiency, lessening the danger of mid-air collisions between planes and crashes into other obstructions, has been developed by the Square D Company's Kollsman Instrument Division.

The development incorporates a sensitive altimeter instrument which automatically corrects itself for barometric pressure changes as a plane flies within the range of special radio transmitters located at ground stations in mountainous regions, at airports and other strategic spots.

The compact, lightweight radio transmitters required for the Automatic Altimeter Setting, as the device is known, are actuated by a ground altimeter, are self-operative and can easily be combined with existing radio range stations. An automatic cut-out device prevents confusion when an airplane is flying within the signalling range of two ground stations: the device automatically cuts out the weaker signal.

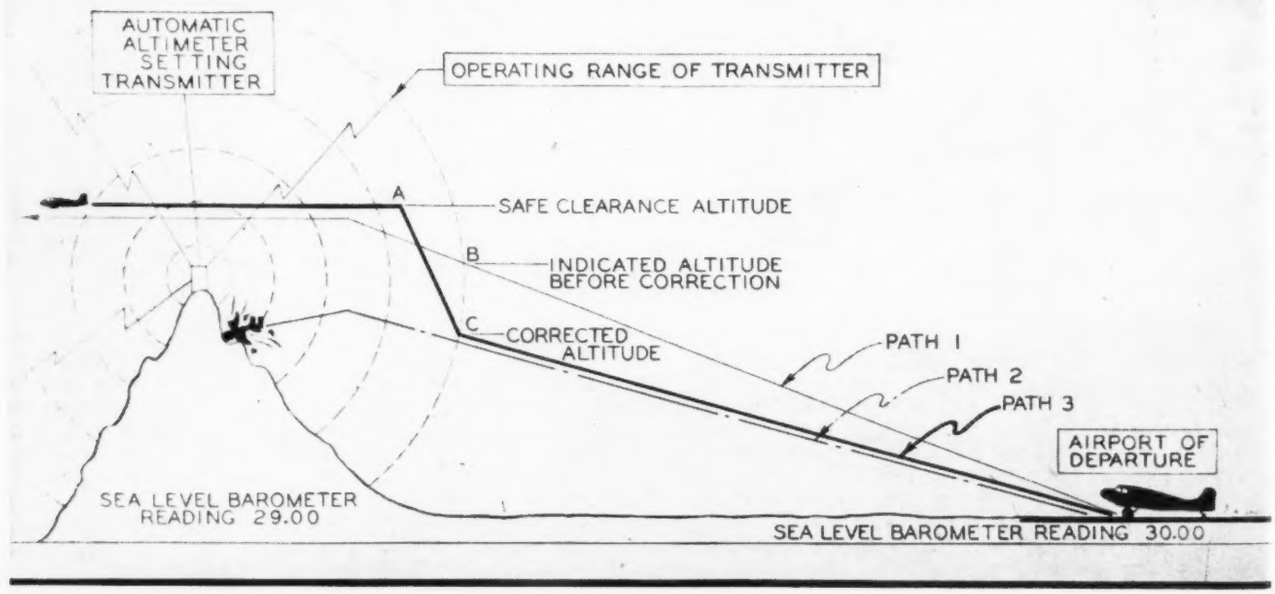
Under the present system the ground operator manipulates an altimeter in such a fashion as to obtain the correct setting (a four digit number such as "three-zero-five-three") and then pronounces the number over the radio. The pilot must hear the number and then remember it long enough to manipulate his Altimeter incorrectly as much as one thousand feet.

In the new device a ground altimeter sends out its own altimeter setting continuously in the form of a coded radio signal. The airplane's altimeter receives this signal, decodes it and sets itself.

THE PILOT PLANS to fly Path 1, having set his altimeter according to the sea level barometric reading at departure.

With only the airport setting the pilot flies Path 2. The sea level barometric pressure gradually drops as the plane approaches the mountain—the altimeter reads higher than it should and the plane crashes into the mountain.

With the automatic altimeter, the pilot follows Path 2 until the plane comes within range of the automatic altimeter setting transmitter. Here the airplane's altimeter receives the correct altimeter setting in the form of a radio signal and automatically adjusts itself; the altimeter pointer moves quickly from the indicated altitude "B" to the actual corrected altitude "C." Noting that he is at a lower altitude than that of his intended course the pilot immediately starts climbing to safe clearance altitude "A," Path 3.



contract with certain research groups and the Navy with others. With Bush at its head, it is not unlikely that the joint Board itself will eventually take over the job of promoting science unless a civilian foundation takes it over first.

The prospects for a civilian foundation are uncertain and becoming more so all the time. The question will certainly come up in the next Congress. If Sen. Kilgore is reelected, he will take up the cudgels again. But the mere fact that a research program is already going forward to the tune of $100,000,000 a year, even though under military auspices, will take away much of the urgency of the foundation proposal.

Atomic Energy Commission Appointed

Conversion of the booming atom industry from its status as primarily a weapon of war to that of peacetime application moved another long step forward with the appointment of the Atomic Energy Commission.

As had been generally expected, David E. Lilienthal was named Chairman. The 47 year old head of Tennessee Valley Authority was chairman of the five-man State Department Board that wrote the Lilienthal-Acheson Report outlining the fundamentals of an international atom control plan now before the U. N. Atomic Commission.

Named to serve with Lilienthal to carry out responsibilities, President Truman designated in a special statement as being "as great as any men have ever assumed in peacetime" are a nuclear physicist who helped create the bomb, a two-time Pulitzer Prize winning editorial writer, and two financial men, one with government regulation experience and the other intimately connected with naval procurement and research. They are:

Robert F. Bacher, Professor of Physics and Director of the Laboratory of Nuclear Studies at Cornell University and wartime assistant to J. Robert Oppenheimer at the Los Alamos atomic bomb factory;

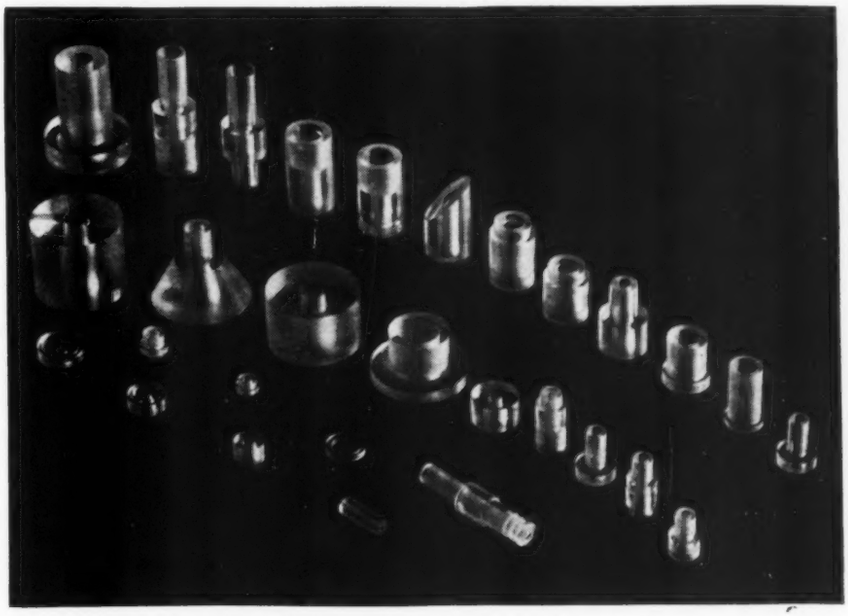
William W. Waymack, Vice President and editor of the Des Moines (Iowa) Register and Tribune, member of several government institutional advisory bodies and just returned from being U. S. observer at the Greek elections;

Lewis L. Strauss, partner in the banking house of Kuhn, Loeb and Co., World War I secretary to Herbert Hoover, and, as a Naval Reserve officer in World War II, originator of the wartime "E" award, Navy member of the Munitions Board and the Inter-Agency Atomic Committee.

Sumner T. Pike, New England and Wall Street gas company promoter who served a term as Republican member of the Securities and Exchange Commission and formerly was a member of the temporary National Economic Committee.

To these five men—at least for the vital formative next two years of their initial term of office—goes the job of developing and operating the first "nationalized" industry in America, an industry that already, as a legacy of its wartime role, consists of "properties and an organization which in magnitude are comparable to the largest business enterprises of the country."

The Commission succeeds Manhattan District as "owner and operator" of the vast atomic plants at Oak Ridge, Hanford, and Los Alamos, and the tremendous research institutions such as Argonne Laboratory at Chicago. It will expand and push Manhattan District's vast peacetime application programs such as the development of atomic-fueled power and mass production of radioactive by-products for research and medicine. It has, under terms of the Atomic Energy Act of 1946 (McMahon Bill), a "monopoly" of production of U235 and plutonium and will license all industrial and academic work in the field. It also assumes jurisdiction over dissemination of all information relating to basic knowledge and discoveries in nuclear physics.



Plastic for High Frequency Precision Parts

A PLASTIC MATERIAL offering advantages in the manufacturing of high frequency insulating applications, has been announced by the plastics division of the General Electric Company. Possessing heat resistance and the ability to be machined to close tolerances, the new material is well adapted as an insulator in electrical connectors. Known as Textolite 1422, the new material possesses a very low power factor with an ASTM heat distortion of 105 to 113 deg. C. It machines well enough to be adaptable to automatic and semi-automatic fabricating equipment. A cast plastic, Textolite 1422 is applicable to small quantity production.

Tests of the new material indicate that, under the light loads commonly encountered in connector assemblies, it will maintain its shape up to 200 deg. C. and, when fully loaded, will surpass the highest operating temperatures recommended for RG type coaxial cables. At this temperature, it does not flow but becomes flexible and, upon cooling, regains its normal rigidity.

General Electric stated that it is a material for structural components in high frequency equipment where the lowest power factor is required and operating temperatures prevent the use of polystyrene.

Textolite 1422 has a dielectric constant at 3000 megacycles 2.4 to 2.5 and a power factor at 3000 megacycles of 0.0006 to 0.0009. These characteristics make it applicable to connector beads, ultra-high frequency antenna and oscillator coils, stand-off insulators, rigid coaxial spacers, large size ultra-high frequency spacers, spreaders and air-wound coil supports, as shown in the photograph.

It has a specific gravity of 1.045 to 1.050; tensile strength of 8000 to 10,000 lb. per sq. in.; flexural strength of 15,000 to 18,000 lb. per sq. in.; compressive strength of 18,500 to 19,000 lb. per sq. in.; impact strength of 0.25 to 0.35 and a Rockwell hardness, H-scale, of 68 to 72.

Industry Decentralization Needed for Security

Dispersal or decentralization of American industry, an integral part of the overall tactical industrial mobilization plan now under development by the Army and Navy Munitions Board, is such a tremendous undertaking that government help in the spending of "astronomical amounts" of money will be necessary. Industry, according to the Board, left to its own devices, is following the right track in decentralization but the resulting movement is so slow

as to prove of no immediate military value. It is evident that the government will have to step in, in the not too distant future, and channel the dispersal into a preconceived military pattern.

Tactical dispersal, so that our key industries could not be crippled or wiped out by one well-plotted concentration of weapons, is one of the great problems confronting the Munitions Board, the highest mobilization planning agency in the country. Richard R. Deupree, president of Proctor and Gamble, and Chairman of the Board, says that there is no immediate answer to the dispersal problem, although the Board is talking and thinking about it.

Congress, necessarily, would have to pass laws making the future stand-by plans, and the resulting revamping of industry possible. There is no thought in the Munitions Board of writing any suggested legislation for the next session of Congress.

Mr. Deupree is in favor of further action by the next Congress to increase the allowable expenditures by the military for stockpiling of critical materials. Appropriations are set at 100 millions for this year. He believes this should be about 360 millions a year for the next five years or so. During this period of materials shortages the Board is going ahead with its buying program cautiously, staying out of crowded markets.

The recent Presidential order giving him final authority in designating joint procurement responsibility between the Army and Navy is not a move toward military unification. The Presidential order, which gives the board chairman the power of final decision in case of a controversy over service procurement, will have a decided effect in standardization of many like items now bought individually.

The Chairman emphasized the fact that the Board is not a purchasing agency, nor a weapon development group, but is actually a coordinating agency between the two services and a planning panel for preparedness in any future emergency.

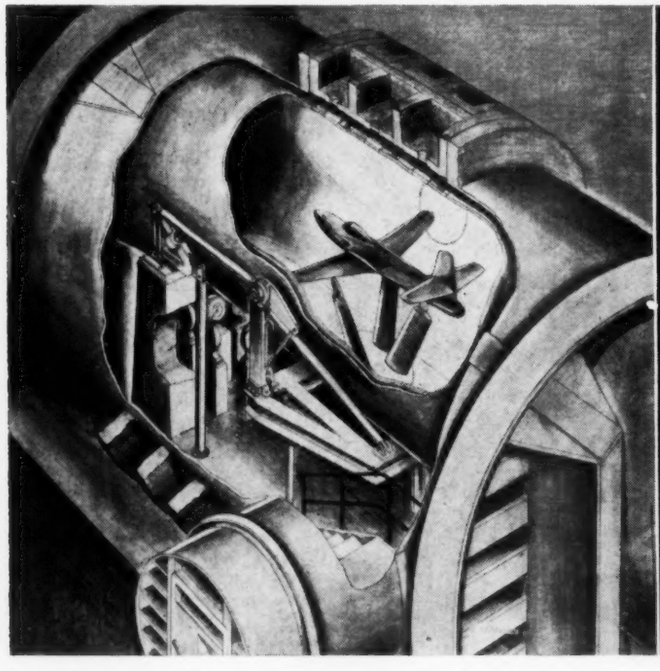
NACA Completes Transonic Wind Tunnel

CAPABLE OF SPEEDS up to the speed of sound, and permitting scientists to secure design information applicable to full size, high-speed aircraft under the most closely duplicated free-air conditions yet attained, a new wind tunnel has been completed at the NACA's Ames Aeronautical Laboratory at Moffet Field, California. Described as the Twelve Foot Low Turbulence Pressure Wind Tunnel, this research tool is a new achievement in wind-tunnel design. The test section is 12 feet in diameter. By increasing the pressure, however, the data secured on airplane models of 10-foot wing span are directly applicable to full-sized airplanes of 60-foot span. The low-turbulance aspect is one of the most important features of the tunnel.

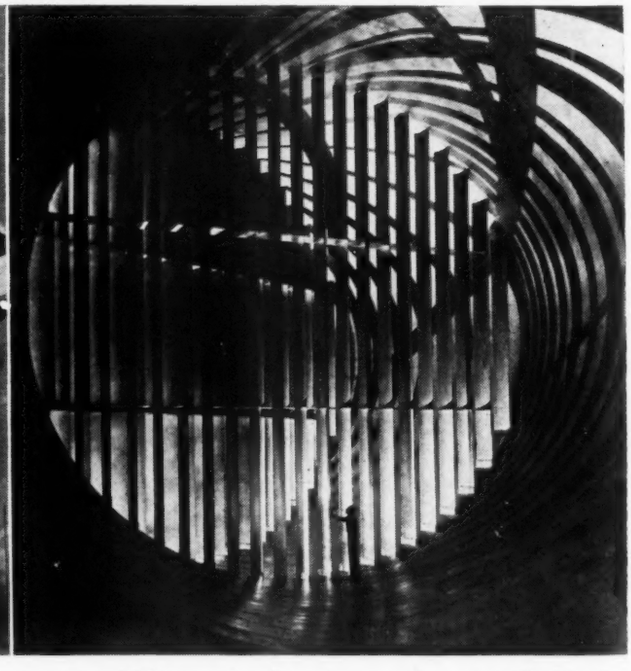
Air is circulated through the tunnel by two 18-ton variable pitch coaxial fans, which are powered by electric motors of 11,000 total horsepower. The tunnel can be "pumped up" to full pressure in less than two hours. By means of large centrifugal compressors, air pressure in the tunnel can be varied from 1/6 to 6 times atmospheric pressure. This represents a range from 2.5 to 88 lb. per sq. in. The purpose of reducing the pressure below atmospheric is to attain greater speed. Increasing the pressure gives the same result as using larger airplane models.

The large spherical bulge gives the tunnel its smoothness of airflow. Inside are stretched eight, fine-mesh wire screens spaced nine inches apart, each one over 60 feet in diameter. These eliminate nearly all the swirling or turbulance in the airstream. The air moves slowly through this section, at only about 20 miles per hour. Combined with the action of the screens is the effect of the very large contraction ratio of 25:1 between the large diameter sphere and the twelve-foot test section. This acts literally to squeeze any remaining turbulence out of the airstream as well as to accelerate the air to the necessary speed.

Since there is no known correction for turbulence in a wind tunnel, it is of the highest importance that it be kept to a negligible minimum. It was in an extreme low-tubulence tunnel of specialized design that it was possible to develop the low-drag laminar-flow series of airfoils that came out of the NACA's Langley Field Laboratory. This, however, was done in two-dimensional airflow, with no span-wise air motion such as is present around actual airplanes. The Ames Laboratory tunnel was built specifically for investigations on complete models in equally smooth airflow. The tunnel is expected to extend the laminar-flow study over a much wider range of development and application.



Model support, force measurement devices and electrical recorders are contained in a pressurized cylindrical section encasing the tunnel test section. This chamber is sealed to the tunnel shell by a steel pressure seal.



A series of fifteen sets of turning vanes are installed in the U-shaped tunnel ends. These vanes direct the airstream smoothly around the turns without loss of speed or change in pressure.

RESEARCH NOTES

Du Pont Opens Akron Rubber Laboratory

A new research laboratory for service to rubber manufacturers of the middle west has been established by the Du Pont Company in Akron. The new building, formally opened on November 22, contains a series of laboratories for experimental work with natural and synthetic rubbers. The stimulation of this closer contact with the rubber industry has an important bearing upon Du Pont research.

Many Du Pont activities parallel those of the rubber industry, especially since the manufacture of rubber goods was one of the first major industries of the country based almost entirely on chemistry. In the early days research for the rubber industry was primarily concerned with curing agents, antioxidants and plasticizers. Concurrently, research on the development of synthetic rubber was being conducted. One result of research on synthetic rubber was neoprene. Other products of Du Pont research which have been promptly adopted and fitted to rubber industry needs are the synthetic fibers. High-tenacity rayon tire cord was developed. Nylon is now finding a place for itself in the manufacture of rubber products. The indications are that even nylon is not the last work.

The facilities of the new Akron laboratory include:

1. A separate latex laboratory equipped to handle practically all phases of experimental work on the use of natural and synthetic rubber latices. A feature of this laboratory is a specially designed automatic dipping machine for simulating plant production of articles from latex. This machine, built of stainless steel and operated by a variable speed motor, has three tanks, one for the latex compound, another for coagulation of the dipped film, and the third for leaching with water. In operation, it first lowers and raises forms, on which the latex is deposited, in and out of the latex compound tank at a uniform speed to avoid uneven deposits of the rubber. After the dipping operation, the coated forms are moved on the machine and lowered into the coagulant, where the deposit is set, and finally into a constant temperature water bath where salts and other undesirable impurities are leached from the film.

2. A mill room equipped with mills, banbury mixer for the preparation of finely divided dispersions and emulsions essential to the compounding of latex; calendar and extruder.

3. A separate weigh-up room.

4. A curing room. An interesting feature of the curing equipment is that it is separated from the working space of the mill room. The hydraulic presses for molding are operated by remote control from outside the inclosing wall. Automatic temperature recorders, gages, and valves are mounted outside the press room, and sliding doors allow access to the press platens. This not only makes for better working conditions but insures a uniform atmospheric temperature surrounding the curing presses.

Dr. Charles J. Mighton, manager of the Du Pont Company's new Rubber Laboratory, formally opened on November 22, in Akron, Ohio.

5. An oven room for accelerated aging tests.

6. An air-conditioned test room with special facilities for low and high temperature testing, measurements of abrasion resistance, heat build-up, flex-or-cut-growth resistance, and other standard evaluations of rubber products.

Dr. Charles J. Mighton will manage the new Akron Laboratories and give particular attention to problems pertaining to natural or synthetic rubber latices. Prior to joining Du Pont's Rubber Chemicals Division, he was research supervisor at the company's Experimental Station in Wilmington, Del., directing various phases of synthetic rubber research.

Armour Publishes Papers on Mexican-American Research

Industrial research in action, from the college laboratory to the extensive applied research programs of industry, is presented in a recent 176 page volume published by the Armour Research Foundation of Illinois Institute of Technology, Chicago. Containing papers by more than a score of the nation's top ranking scientists, educators, industrialists and researchers, the volume includes the complete proceedings of the week-long Mexican-American Conference on Industrial Research sponsored last fall by the Foundation. The conference, which provided an opportunity for more than thirty outstanding leaders from Mexico to obtain an insight on methods used in the solution of research problems in this country, was termed "the most practical demonstration of the good-neighbor policy that has been given to any Mexican" by the south-of-the border delegates.

According to Dr. Jesse E. Hobson, director of Illinois Tech's Armour Research Foundation, this book will prove of value to everyone with an interest in industrial progress through research. Representative types of university research, foundation research, government research, and private industry research are described, as well as general patterns on both the national and international front, are described and discussed.

Among the authors whose papers are included, are such men as Dr. Edward R. Weidlein, director of the Mellon Institute; Harold A. Vagtborg, president of Midwest Research Institute; David Levinger, vice president of Western Electric Company; Dr. Gustav Egloff, director of research, Universal Oil Products Company; Dr. I. L. Baldwin, dean of the graduate school, University of Wisconsin; Dr. A. A. Potter, then president of Purdue University; Mr. Eugene C. Crittendon, assistant director, National Bureau of Standards; George S. Case, vice president, American Standards Association; James Drumm, vice president, National City Bank of New York, and others.

Copies of the "Proceedings of the Mexican-American Conference on Industrial Research" can be obtained for $2.50 from S. Charles Papageorge, Armour Research Foundation, Technology Center, Chicago 16, Illinois.

Stanford Research Institute

The establishment of Stanford Research Institute, a non-profit organization, as a factor in the development of industrialization in the Far West has been announced by Dr. Donald B. Tresidder, president of Stanford University. All research problems of industry, he stated, are within the scope of the new institute. In this respect it differs from institutions in other parts of the United States that restrict their operations to research in the natural sciences. Pure and applied research in the physical, biological and social sciences, engineering and the mechanical arts are within its scope.

Leading industrialists of Southern and Central California and of the Pacific Northwest have cooperated in the organization of the institute, rather than undertaking the establishment of separate and smaller institutes in various localities. At Stanford, the institute, while it is a distinct organization, will draw upon the reservoir of scientific ability found within the university faculty, in addition to its own staff of scientists and technicians. Existing scientific laboratories on the campus also will be utilized, particularly in related research of a fundamental nature.

Director of the institute will be Dr. William F. Talbot, president and technical director of the Fine Chemicals Division of the Sun Chemical Corp. During the war he served as assistant director of the re-

search and development branch of the Office of Strategic Services, developing secret weapons. He is the inventor of the melamine plastics.

Paper on Gearing Relates Pitting to Surface Stresses

T. H. Wickenden, G. R. Brophy and A. J. Miller presented at the American Gear Manufacturers Association's 30th annual meeting the first technical paper to show definitely that pitting of gears is a fatigue phenomena, the occurrence of which can be related to the magnitude of the surface compressive stresses.

The paper, entitled "An Operating Test For The Evaluation of the Surface Durability of Gears" described a testing machine designed through the cooperation of the Research Staffs of General Motors and International Nickel for testing gears. Test data were presented to demonstrate the results obtained on gears made of SAE 4645 nickel-molybdenum steel quenched and tempered to three hardness levels. "A Unique noise meter is employed to determine the failure point of the test gears by measurement of the change in the amount of noise developed," the authors stated. "As an ultimate aim, the testing program will be able to compare materials for gear construction and enable the producer to select the best steel and heat treatment for long-lived gears," they added.

Mr. Wickenden is the head of the Development and Research Division of The International Nickel Company. Mr. Brophy is in charge of the Steel Research Section at its Bayonne Research Laboratory and Mr. Miller is also associated with this Section.

First Supersonic Airplane Built For Research

THE FIRST PILOT-CARRYING AIRPLANE designed to travel faster than sound has been built as a research tool to probe the realm of supersonic flight not yet penetrated by man. The XS-1 has been constructed by Bell Aircraft Corporation under contract to the Army Air Forces, and is based on high-speed design information provided by the National Advisory Committee for Aeronautics. The airplane has already been flown in upward glide tests, and is soon to make the first rocket powered flights.

Designed to fly at a top speed of 1700 m.p.h. at an altitude of 80,000 feet, the XS-1 was never intended to be a military airplane. It is actually a piloted flying research laboratory, the sole function of which will be the recording of data on the effect of transonic and supersonic speeds on an aircraft.

The XS-1 has already flown—but not at supersonic speeds and not under it own power. It has been carried to altitude by a B-29, release and allowed to glide to earth. Because present plans call for loading the ship heavily with scientific equipment, the first flight of the XS-1 will necessarily be a short one. Consequently, it will be necessary to employ the B-29 again as a tow-craft. Released at altitude, the XS-1 will then be subjected to its rocket power.

The XS-1 is an extremely rugged airframe driven by a powerful rocket engine. Since it is not a combat plane, it has no armament or armor protection for the pilot. Surprisingly, for a plane designed to fly at speeds faster than man has ever flown before, the XS-1 employs a rather conventional configuration. Though highly streamlined, the use of the sweptback wing has been avoided. The wing is very thin, with a maximum thickness of only ten percent of the chord. After initial test work has been completed, it is planned to try other wing designs incorporating the knowledge gained by experience with the test model.

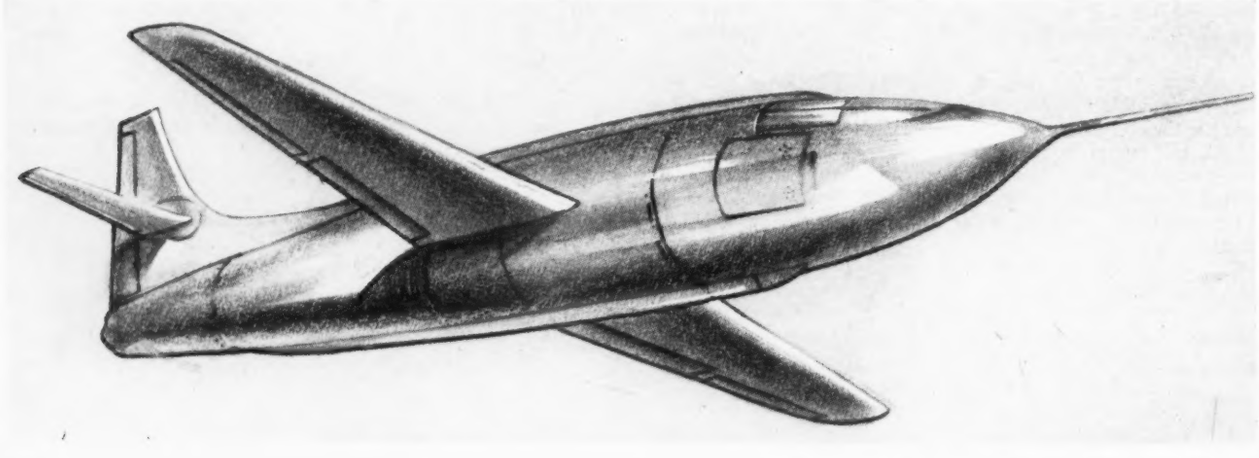
Power for the XS-1 is supplied by an engine designed and manufactured by Reaction Motors, Inc. This consists of four units, burning alcohol and liquid oxygen, each of which produces a static thrust of 1500 pounds, or a total thrust output for the plane of 6000 pounds. Power output is controlled by selection of the number of cylinders to be fired at one time. Thus, the pilot can use 1500, 3000, 4500 or full 6000 pounds thrust at his choice.

In the first model of the XS-1, the plane will not be capable of attaining the speed for which it was designed, because of the substitution of an alternate power plant. The original power plant installation was to have incorporated a fuel system wherein alcohol and oxygen would be forced into the burner chambers by a specially designed turbo pump. It soon became apparent, however, that the many problems which design of this turbo unit presented would delay its construction until considerably after the XS-1, in all other respects, would be ready for its first powered flight, and so an alternate was adopted.

In the alternate design, a pressurized system is employed, with gaseous nitrogen being used to force the liquid oxygen and alcohol into the burners. As a consequence, the XS-1 fitted with the pressurized system can operate for only 2.5 minutes at full 6000 pound thrust, compared to 4.2 minutes when equipped with the turbo pump system. In addition, top speed for the alternate power unit is estimated at one thousand m.p.h. at 60,000 feet, instead of the 1700 m.p.h. velocity at 80,000 feet for which the plane was designed. The rate of climb of 45,000 feet per minute claimed for the turbo unit falls off to 28,000 feet per minute when the alternate engine is substituted.

The length of the airplane is 31 feet, it measures 10 ft. 10 in. from ground to tail-top; its wing span is small compared to the AAF's latest fighter craft—only 28 feet. The wing area is 130 feet. The unloaded weight of the plane, equipped with the turbine pump version, is 4,892 pounds, 526 pounds of which is test equipment. The rocket fuel weighs more than one and one-half times the weight of the empty plane—8,177 lb. The overall weight of a fully loaded XS-1 will be 13,069 lb. Range will be extremely short, being little more than 100 miles.

The wings have an aluminum alloy skin machined out of solid stock, so as to permit a thickness at the butt of more than 1/2 in., while it tapers off to only slightly more than 1/8 in. at the tips. Overall, the plane is designed to stand a force of 18G thus representing the most sturdy airplane ever built.



A.G.M.A. Semi-Annual Meeting Features Splines, Surfaces

More than 300 representatives of gear manufacturers attended the 1946 semi-annual meeting of the American Gear Manufacturers Association at the Edgewater Beach Hotel, Chicago, October 27 to 29. High lighting the general meeting was a written discussion presented by Louis D. Martin, Gear Engineer of Eastman Kodak Company on Evaluating Surface Roughness of Gear Teeth. As chairman of the Fine Pitch Gear Committee, Mr. Martin threw open for discussion the whole problem of surface roughness determination as applied to gear teeth. The purpose of this discussion was to obtain expressions of opinion to aid the Fine Pitch Gear Committee and the Inspection Committee in setting up a program in connection with surface roughness evaluation. Much of the discussion from the floor made reference to the article, "A New Approach in Evaluating Surface Roughness of Gear Teeth," by Louis D. Martin, that appeared in the September Product Engineering. There were numerous privately expressed opinions that there will be highly significant progress during the coming year on the problem of gear tooth surface roughness by the two committees, previously mentioned.

Mr. H. Pelphrey of Michigan Tool Company and chairman of the Splines Committee announced that the American Standards Association has approved the American Standard Involute Splines. This standard was developed by the joint efforts of committees of the A.G.M.A., the A.S.M.E., the National Machine Tool Builders Association and the S.A.E. Mr. Charles Stanard of the Buick Motor Division of General Motors Corporation was chairman of the S.A.E. committee and played a leading part in the development of this standard. A detailed analysis of the design and application of involute splines was presented by him in the March 1945 number of Product Engineering.

Twelve of the engineering committees held sessions and reported progress at the closing session of the General Engineering Committee. The Material Committee under the chairmanship of E. J. Wellauer

Foreign Reports

. . . . . from McGraw-Hill World News

New International Standards Body Formed

A new International Organization for Standardization has been born as the result of a conference of the representatives of the national standards association of 25 countries, held in London from October 14 to 26 under the auspices of the United Nations Standards Coordinating Committee.

Formation of this new body, which will remain independent of the United Nations organization, is claimed to provide a framework within which the engineers of all countries can work together to reach agreement on a common basis for standards established by their national groups.

The I.S.O., which takes over the functions of the old International Standards Association, and will carry on and expand those activities, start life assured of a much more secure financial backing than its predecessor enjoyed. This means that it will have a more adequate staff, and be assured of stronger support from national associations much more aware of the value of common standards.

The high standing accorded America's technical prowess at this conference culminated in the group's unanimous selection of an American to be the first president of the new organization—Mr. Howard Coonley, chairman of the executive committee of the American Standards Association and a vigorous exponent of standardization.

The Russian delegation displayed a gratifying willingness to cooperate fully with the other countries, and inserted no provisions for a veto-power and made no claims for a permanent seat on the Council. The single insistence was for the inclusion of Russian as the third official language (with English and French) for publications of the new organization.

The constitution of the new body, which will go into effect when it has been ratified by 15 nations, provides for a General Assembly, to meet every three years, in which each member-nation will have one vote. The conference just concluded will have been, in effect, the first meeting of this General Assembly; its next, probably, will be held in 1949. A Council, composed of eleven members chosen by the Assembly, will be the functioning administrative body of the I.S.O. between sessions of the larger group. For the first five years, five nations (the U.S.A., the United Kingdom, Russia, France and China) will each hold one seat on the Council; the other six members will be elected for three-year terms, with two of the six retiring each year. To set this overlapping scheme in operation, Norway and Austria, selected as members of the first Council, will serve four-year terms; Belgium and India will serve three-year terms; and Brazil and Switzerland will serve two-year terms.

In new organization, any member-nation may propose a subject on which it feels there is possibility for agreement; this suggestion is circulated among the entire membership; if five members concur, the proposal is brought before the Council. This group then determines what action shall be taken; if favorably inclined, it assigns the project to a working committee, which is assisted by the technical resources of one or more countries. When the committee has finished its work, the report is considered by the General Assembly; and if passed by three-fourths of this group, the contents will be issued as a "recommendation" of the I.S.O. to the national standards group for all member-countries. These groups then are free to promulgate the agreed-upon basis as a national standard for their respective countries, or to reject it, as they see fit.

The term "international standard" will not be used to refer to any such agreed common standard unless all members of the I.S.O. have adopted it and placed it into effect.

Practically the whole field of business and technology will come within the purview of the new organization. Some 15 new proposals for standards' unification were put forward at this conference, and these, with the 50-odd projects assumed from the old I.S.A., extend the new body's studies into essential oils, vegetable oils, ball bearings, unfired pressure vessels, the classification of electric motors, and other projects.

Gustave L. Gerard, president of the Institute Belge de Normalisation, was elected vice-president of the new organization, and M. F. Streiss, of Switzerland, treasurer. Dr. Paul G. Agnew, secretary of the A.S.A., and F. C. Crittenden, of the National Bureau of Standards, represented the United States. A general-secretary for the group will be selected between now and the first meeting of the Council, which has been called for May, 1947; meanwhile, the necessary administrative work will be carried on by the United Nations Standards Coordinating Committee office in London, which will dissolve when the I.S.O. begins to function. Geneva was chosen as the permanent headquarters for the body.

New Steel-Making Process

A process using oxygen instead of air blast in blast furnace smelting is being developed by Soviet engineers. The development was made possible by the invention of a cheap means of producing oxygen, the details of which have not been announced. V. Kondakov, vice chairman of a state bureau for the use of oxygen in metallurgy, claims that the oxygen blast method can eventually lead to a continuous process for making steel, eliminating converters and ingot soaking pits.

of the Falk Corporation announced the final approval and official release of the A.G.M.A. Standard 242.02 covering cast iron gear blanks.

Gear Experts Receive Naval Ordnance Awards

AT A CEREMONY held at the Gleason Works in Rochester, N. Y., Allan H. Candee and E. T. Slayton were presented naval ordnance development awards for their work in the research and development of power drive and control gearing for 5-inch gun mounts. Commander R. H. Solier, naval inspector stationed at Bausch & Lomb, made the awards and read letters of appreciation by Vice Admiral G. F. Hussey, Jr., Chief of Naval Ordnance.

Book Labeling Kept Up To Date

THE MCGRAW-HILL BOOK COMPANY, in its 1946 Catalog, for the first time is labeling each book as to year of publication or last revision. Dating may be of particular importance in books on science and technology, or when dated government or professional codes affect practice. However, the policy of changing the date on the title page only when the book is revised has not been changed.

MEETINGS

December 9-11
Society for Experimental Stress Analysis—Annual meeting, including a Symposium of Telemetering of Aircraft Flight Observations, Hotel New Yorker, New York, N. Y.

December 9-14
Automotive Service Industries Show—Atlantic City, N. J.

December 26-29
American Mathematical Society—Annual meeting, Swarthmore College, Swarthmore, Pa.

January 6-8
Society of Automotive Engineers—Annual meeting, Detroit, Mich.

January 14-17
Material Handling Exposition—Public Auditorium, Cleveland, Ohio.

January 27-31
American Institute of Electrical Engineers—Winter meeting, New York, N. Y.

January 27-31
International Heating and Ventilating Exposition—Lakeside Hall, Cleveland; concurrent with meeting of American Society of Heating and Ventilating Engineers.

January 28-February 2
Society of Plastics Engineers—Annual meeting and exhibition, Congress Hotel and Navy Pier, Chicago, Ill.

RECENTLY ELECTED SOCIETY OFFICERS

Industrial Research Institute, 60 E. 42 St., New York 17, N. Y. President—C. S. Venable, American Viscose Corp.; Vice President—N. A. Shepard, American Cyanamid Co.; Secretary Treasurer—C. G. Worthington.

American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio. President—A. L. Boegehold, General Motors Research Laboratories; Vice President—F. B. Foley, Midvale Co.; Secretary—W. H. Eisenman.

Malleable Founders' Society, Union Commerce Bldg., Cleveland 14, Ohio. President—Frank E. Shumann, Lehigh Foundries; Vice-President—Wilson Moriarty, National Mall. & S. C. Co.; Executive Vice President—H. S. Colby; Secretary- Treasurer—John J. Harant.

American Society of Mechanical Engineers, 29 W. 39 St., New York 18, N. Y. President—Eugene William O'Brien, W. R. C. Smith Publishing Co.; Secretary—C. E. Davis.

Packaging Machinery Manufacturers Institute, 342 Madison Ave., New York 17, N. Y. President—George W. von Hofe, New Jersey Machine Corp.; Vice President—Boyd H. Redner; Vice President—Oscar W. Wikstrom.

Society of Industrial Designers, 55 W. 42 St., New York 18, N. Y. President—Raymond Loewy; Vice President—Harold Van Doren; Secretary—Egmont Arens; Treasurer—Ray Patten.

Society of Automotive Engineers, 29 W. 39 St., New York 18, N. Y. President—C. E. Frudden, Allis-Chalmers Mfg. Co.

American Rocket Society, 29 W. 39 St., New York 18, N. Y. President—Lovell Lawrence, Jr.; Vice President—Roy Healy; Secretary—G. Edward Pendray.

American Society for Testing Materials, 1916 Race St., Philadelphia, Pa. President—Arthur W. Carpenter, B. F. Goodrich Co.; Vice President—Richard L. Templin, Aluminum Company of America.

DISCUSSIONS AND COMMENTS FROM READERS

Corrections in "Carbon and Alloy Steels for Cold-Formed Springs"

To the Editor:

In my article on "Carbon and Alloy Steels for Cold-Formed Springs" which appeared in your October issue, I find on page 119 that a zero was left out and the last sentence should read "while springs 0.011 in.", instead of 0.110.

On page 122, in talking about 18-8 stainless steel with 2—3 percent of Moly it is listed as A.I.S.I. type 36; it should be 316.

—F. P. ZIMMERLI
Barnes-Gibson-Raymond Div.
Associated Spring Corp.

Improving the Designer's Position

To the Editor:

I have read with great interest your editorial about the designer's drift to other fields (see PRODUCT ENGINEERING, April, 1946). One of the causes given is a drop of interest in that branch of engineering. This fact could be explained by unhealthy relations between top management and designers. An example is the bureaucratic treatment of drafting room employees; visiting workshops and discussing the design job with production workers is not encouraged. The designer working steadily at the drafting board, is not able to follow the manufacturing process of the designed parts and does not know how his ideas work out from engineering and commercial standpoints.

On the other hand, the common view that workshops are exclusively manufacturing personnel is handicapping the designer's work. It is no surprise that the designer visiting workshops is treated as a foreign person, not a collaborator. It is thus evident that the necessity of building up the authority of designers is urgent. Visiting workshops and personnel attendance at tests of the designed piece should be obligatory. At the same time, the designer should be in close contact with the cost estimating department, collecting data that will enable him to cut the manufacturing cost of machine parts. The additional time will increase the cost of design, but securing the best and cheapest solution of engineering problems will balance this disadvantage.

As the responsibility of the designer grows, we can expect full recognition of the importance of his work and encouragement by bonuses and awards. The new importance of the designer will not only keep him at his post, but will attract new personnel to perform design jobs with enthusiasm.

—VICTOR TATARINOV
Pilsen, Czechoslovakia

"Poor Recognition Breeds Frustration"

To the Editor:

My sincerest congratulations on your April editorial. A copy of that editorial ought to hang in the office of the President of every company in the country.

Production men win bonuses for high production rates, salesmen receive awards for "over-the-top" sales, but the engineers who made it all possible are still receiving their usual salaries. My friends have all had this experience and hope you keep hammering at that point.

—S. A.

NEW BOOKS

Principles of Tool Engineering

RAYMOND R. BLOOM, 234 pages, 6 x 9 in. Rust clothboard covers, published by the McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 18, N. Y. Price $2.40.

An elementary text for vocational trade extension and college students who wish to be introduced to the fundamentals underlying tool engineering in the average manufacturing plant. Professor Bloom has not attempted to go far into tool design, but he has provided the student with a compact introduction to the world of the machine tool shop. The text, after introductory chapters on systems of production, interchangeability, methods of dimensioning and the objectives of tool engineering gives the beginner an excellent survey of types of machine tools. Chapters are devoted to milling machining, milling fixtures, drilling machines and turret lathes. Other chapters cover locking and clamping, jigs, gages, structural materials, tool materials and inspection. One of the last chapters is devoted to twenty problems in elementary tool engineering, such as the design of fixtures, milling and drilling a valve crank or a motor pad. The book is excellent in its coverage but extremely elementary.

Principles of Physics

FRANCIS W. SEARS. Two volumes, 526 and 434 pages, 6¼ x 9¼ in., blue clothboard covers. Published by Addison-Wesley Press, Inc., Cambridge 42, Mass. Price $12.00.

This book, as the title indicates, emphasizes physical principles. Historical background and practical applications have been given a place of secondary importance. Volume I covers mechanics, heat and sound; Volume II covers electricity and magnetism. Most of the problems are taken from examinations that have been given in connection with the two year course in general physics at the Massachusetts Institute of Technology.

The Metallurgy of Quality Steels

CHARLES M. PARKER. 239 pages 6 x 9 in. Black board covers. Published by Reingold Publishing Corp., 330 W. 42nd St., New York, N. Y. Price $6.00.

This book, an outgrowth of the author's work as Secretary of the General Technical Committee of the American Iron and Steel Institute in answering questions and lecturing was written to provide the nonmetallurgist with an introduction to the science of metallurgy. Its exceptionally clear and concise explanation of the nature and manufacture of steel, the inspection and mechanical testing of steel and the effects of alloying elements in steel make it a most adequate introduction to metallurgy.

The book is especially noteworthy because of its use of case histories to explain the various methods of making steel; its comparison of the characteristics of steel made by the various steel making processes and its comprehensive discussion of the effects of the various alloying and incidental elements commonly present in steel.

Because of the quantity of actual data presented in connection with the explanation of the various phases of metallurgy covered in this book it should be valuable to the metallurgist as a reference book.

Electrical Transmission is Steady State

PAUL J. SELGIN, Research Engineer, Farnsworth Television and Radio Corp. First edition, 427 pages, 5¾ x 8½ in., blue clothboard covers. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd Street, New York 18, N. Y., as volume in their Radio Communication Series. Price $5.

A technical book built on a mathematical framework and aimed at broadening and strengthening the understanding of fundamental theory and methods of analysis and computation.

The book includes some specialized subjects that may be new to some readers such as, the multisection transformer, generalized selectivity, and the exponential line. The 17 chapters include discussions on four-terminal networks, network constants, distortion in transmission lines, power flow, matching devices, Maxwell's equations, coupling methods and four-pole theory applied to the vacuum tube. Most chapters have illustrative examples.

Applied Elasticity

JOHN PRESCOTT. 666 pages, 5½ x 8½ in. Green clothboard covers. Published by Dover Publications, 1780 Broadway, New York 19, N. Y. Price $3.95.

This is the first American edition of a well-known English book. The subject matter presented is intended for use by engineers. The scope of content is more advanced than that covered in the general college textbooks dealing with strength of materials, but the use of advanced mathematical theories of elasticity is confined to that necessary for the solution of practical engineering problems.

One departure from strict mathematical theory is in the use of approximate methods of solution based on the principle of minimum energy. The methods can be applied to many types of problems such as determining buckling loads and periods of normal oscillations of elastic bodies.

The book does not include any practice problems. The discussion throughout the text is a rigorous mathematical analysis and application of the theories of elasticity that are the foundation of analytical engineering design. The book is written from the point of view of the engineer rather from that of the mathematician.

The Aluminum Industry

STANLEY V. MALCUIT. 34 pages 6 x 9 in. Grey paper covers. Published by Bellman Publishing Co. Inc., 83 Newbury St., Boston, Mass. Price $1.00.

This monograph is one of a series of seventy-five occupational booklets prepared for use in general counseling work or for individual reference in the choice of a career. It contains a brief history of the growth of aluminum from a chemical curiosity to a metal industrial importance and a discussion of the various steps in the process of producing and fabricating aluminum. The duties, qualifications and educational background required by the various positions in the aluminum industry are listed. The monograph closes with a frank discussion of the employment opportunities offered by the aluminum industry and of its advantages and disadvantages to a potential employee.

Finishing Metal Products

HERBERT R. SIMONDS and ADOLPH BREGMAN. Second Edition. 352 pages, 5½ x 8⅜ in. Blue clothboard covers. Published by the McGraw-Hill Book Co., Inc., 334 W. 42nd St., New York 18, N. Y. Price $4.00.

The second edition considers the finishing of metal products from a broad point of view. Emphasis is placed on more attractive metal finishes and method of producing them efficiently. The technique involved in metal finishing is described together with the pre-finishing processes of cleaning and descaling. In addition, the commercial aspects, the sales value of attractive finishes, and the effect of color are included. The economics of metal finishing, the required equipment and the design of parts that require finishing, are likewise discussed in detail.

Manual of Design for Arc Welded Steel Structures

LAMOTTE GROVER. 281 pages. 6 x 9 in. Black Fiber Covers. Published by Air Reduction Sales Co., New York, N. Y. Price $2.00.

This manual, intended especially for use in building construction, is also useful to the designer of welded steel assemblies of machine elements. It contains not only a discussion of the fundamentals of welding design, inspection and cost estimating but also detailed information concerning the proper location of welds, charts showing the strength characteristics of various welded assemblies and tables giving the allowable loads for various welded beams. The manual also contains the latest revisions of the specifications pertaining to both welded structures and electrodes.

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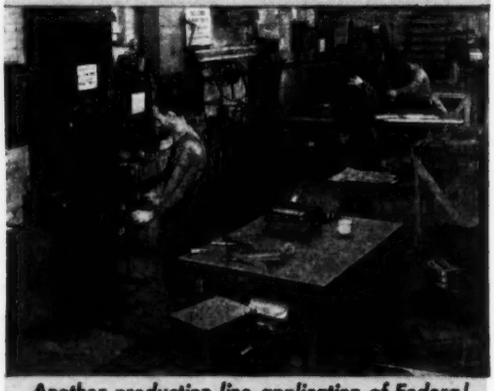
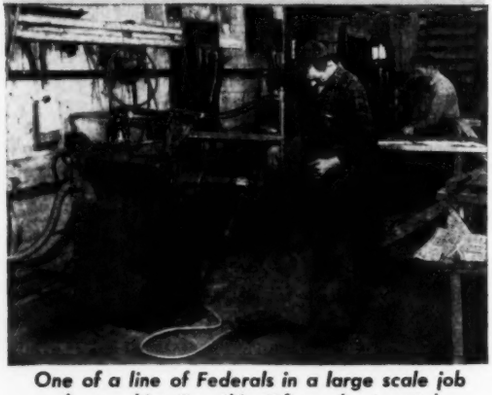
Federal Welders Raise Standards of Metal Fabrication... In Small Shop or Large Plant



Another production line application of Federal Rocker Arm Spot Welders.



One of a line of Federals in a large scale job shop making "anything" from sheet metal.

The business of making things from metal has come a long way since the days when everything from rainspouts to refrigerator liners was roll-seamed and soldered, not too many at a time, by craftsmen known (with all due respect) as "Tin Knockers". Today Federal Spot Welders play a big role in making Metal Fabricators out of such craftsmen.

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MEMBER RWMA

INCENTIVES FURNISH THE DRIVE

THE COMING YEAR, 1946, and the years to follow can bring unprecedented prosperity to the people of the United States if the incentives to secure it are provided.

We have the advantage of starting with an economy which has demonstrated a capacity for expansion unequalled in any other country in the world. Our economy has demonstrated, also, one grave weakness—a recurring interruption of the upward trend of production and living standards by wasteful and paralyzing periods of recession. Recovery from each depression always has carried us to new heights of economic welfare, but the toll of the years of blight has been harmful to everyone.

The job ahead of us is a dual one. We must maintain the vitality of an economy which, over the years, has yielded an enormous increase in the American standard of living, and we also must improve its stability.

The Dynamics of American Production

In the last prewar year, 1940, the population of the United States was 3⅓ times as large as it was in 1870. But the national production, measured in dollars of constant purchasing power, was 10 times as large at the end of the period, and industrial output had increased 20-fold.

In the meantime, the average number of hours of factory workers had been reduced from about 63 per week in 1870 to less than 40 in 1940, while average hourly earnings had more than trebled in dollars of constant purchasing power. Thus "real" weekly or annual wages in manufacturing had doubled over the 70-year period, even though the work-week was cut by 35 per cent. This was made possible chiefly by a tremendous increase in the quantity and quality of the mechanical facilities which were provided in American manufacturing industry. Manufacturing capital investment per worker was multiplied by 6 times over the period in question. But the return per dollar invested, while it has fluctuated widely between good years and bad, showed no general upward trend over that portion of the period for which measurement is practicable.

Incentives in American Manufacturing

There has been, historically, a remarkably consistent pattern in the division of the realized income from the expanding manufacturing output of America. Reliable statistics are not available for as far back as 1870, but from 1899 through 1939 the average share of wages and salaries has been 82½ per cent against 17½ per cent as the share to investors (including dividends, interest, rents, royalties, and non-corporate profits). There have been, from year to year, relatively minor divergences from this pattern of distribution, but there is no discernible trend during the period away from the averages cited.

It is suggested that the persistence of the average 17½ per cent share of realized income from manufacturing that was maintained for the 40 years preceding World War II may represent the proportion that is needed to produce the dividends, interest, rents, royalties, and non-corporate return that will provide for the continuing investment upon which an expanding productivity such as we have had in the past depends. At any rate, it would seem reckless to depart too radically from such an established pattern at a time when unprecedentedly large private capital investment is counted on to make up for the drastic curtailment of such investment during the war years, and to carry us to the new high levels of civilian production set as our postwar goals.

The Distribution of Manufacturing Income in War

At the beginning of the war, the Government adopted controls and a tax program designed to prevent wartime activity from resulting in un-

duly swollen private returns. Due primarily to huge volumes, the profits *before* taxes of manufacturing industry were very high, but throughout the war its profits *after* taxes averaged returns no larger than they had been in good prewar years. Relative to volume, they were considerably lower than in prosperous years in the past. Again, there can be no complaint at results that generally were in accord with a national wartime policy.

But it is fair to note that the wages of manufacturing labor were allowed to increase substantially during the war. Between January 1, 1941 and April, 1945, average weekly earnings per worker increased by 77 per cent. This was, in considerable part, a result of increased working hours and a shift from low- to high-paid industries, but straight-time hourly earnings on the same jobs increased about 40 per cent against a cost-of-living rise of about 30 per cent.

The net result was to alter drastically the 40-year relationship of the 17½-82½ per cent division of Realized Income from Manufacturing. The share of wages and salaries increased to over 90 per cent, and the investment share shrunk to less than 10 per cent.

Its Postwar Distribution

This wartime shift in the proportion of distributive shares has an important bearing upon current wage controveries. With union demands for wage increases ranging up to 30 per cent, and the economists of the Office of War Mobilization and Reconversion asserting that an average increase of 24 per cent is feasible without raising prices, it is pertinent to inquire how such increases would affect the prewar ratios that governed realized income distribution in manufacturing.

Forecasting is always hazardous, but if we assume (1) that in 1946 we shall reach the $160 billion level of national output which the Government proponents of general wage increases expect, and (2) that there will be little increase in productivity because of the continuing process of reconversion, and (3) that the Government will succeed in carrying its announced purpose to maintain present price ceilings, it appears that a 24 per cent general wage increase would reduce the share going to capital from 17½ per cent to 11 per cent even allowing for its increased return resulting from the repeal of the excess profits tax. The prewar ratios would be about maintained if wages remained at present levels.

Conclusion

Since the maintenance of these prewar ratios was accompanied by an unparalleled rise in the "real wage" of American workers, there is a powerful prima facie case for not tinkering with them. It should be noted, however, that some economists think that the size of the investment share of manufacturing income tends to provide more capital than can be absorbed by a mature economy, and thus contributes to those breaks in the expansion of the economy which, as stated at the outset, have been its principal blight.

Regardless of what may ultimately prove to be the validity of this view, no one can responsibly contend that at this early but crucial stage in the reconversion process is the time to test it. Now, no one knows whether, or what dimension of, additional wage increases can be supported without forcing up prices or reducing profits to a point that will discourage vitally needed private capital investment.

We want high and increasing wages in American manufacturing. We need them to provide an active incentive to workers to support expanding productivity, as well as to continue the trend of rising living standards in America. Equally, we need a continuing profit incentive of sufficient attractiveness to call forth the new investment upon which expanding productivity depends.

We can never attain our dual objective if we push one of these aims so far and so fast that it defeats the other.

President, McGraw-Hill Publishing Co., Inc.

INCENTIVES FURNISH THE DRIVE

THE COMING YEAR, 1946, and the years to follow can bring unprecedented prosperity to the people of the United States if the incentives to secure it are provided.

We have the advantage of starting with an economy which has demonstrated a capacity for expansion unequalled in any other country in the world. Our economy has demonstrated, also, one grave weakness—a recurring interruption of the upward trend of production and living standards by wasteful and paralyzing periods of recession. Recovery from each depression always has carried us to new heights of economic welfare, but the toll of the years of blight has been harmful to everyone.

The job ahead of us is a dual one. We must maintain the vitality of an economy which, over the years, has yielded an enormous increase in the American standard of living, and we also must improve its stability.

The Dynamics of American Production

In the last prewar year, 1940, the population of the United States was 3⅓ times as large as it was in 1870. But the national production, measured in dollars of constant purchasing power, was 10 times as large at the end of the period, and industrial output had increased 20-fold.

In the meantime, the average number of hours of factory workers had been reduced from about 63 per week in 1870 to less than 40 in 1940, while average hourly earnings had more than trebled in dollars of constant purchasing power. Thus "real" weekly or annual wages in manufacturing had doubled over the 70-year period, even though the work-week was cut by 35 per cent. This was made possible chiefly by a tremendous increase in the quantity and quality of the mechanical facilities which were provided in American manufacturing industry. Manufacturing capital investment per worker was multiplied by 6 times over the period in question. But the return per dollar invested, while it has fluctuated widely between good years and bad, showed no general upward trend over that portion of the period for which measurement is practicable.

Incentives in American Manufacturing

There has been, historically, a remarkably consistent pattern in the division of the realized income from the expanding manufacturing output of America. Reliable statistics are not available for as far back as 1870, but from 1899 through 1939 the average share of wages and salaries has been 82½ per cent against 17½ per cent as the share to investors (including dividends, interest, rents, royalties, and non-corporate profits). There have been, from year to year, relatively minor divergences from this pattern of distribution, but there is no discernible trend during the period away from the averages cited.

It is suggested that the persistence of the average 17½ per cent share of realized income from manufacturing that was maintained for the 40 years preceding World War II may represent the proportion that is needed to produce the dividends, interest, rents, royalties, and non-corporate return that will provide for the continuing investment upon which an expanding productivity such as we have had in the past depends. At any rate, it would seem reckless to depart too radically from such an established pattern at a time when unprecedentedly large private capital investment is counted on to make up for the drastic curtailment of such investment during the war years, and to carry us to the new high levels of civilian production set as our postwar goals.

The Distribution of Manufacturing Income in War

At the beginning of the war, the Government adopted controls and a tax program designed to prevent wartime activity from resulting in un-

duly swollen private returns. Due primarily to huge volumes, the profits *before* taxes of manufacturing industry were very high, but throughout the war its profits *after* taxes averaged returns no larger than they had been in good prewar years. Relative to volume, they were considerably lower than in prosperous years in the past. Again, there can be no complaint at results that generally were in accord with a national wartime policy.

But it is fair to note that the wages of manufacturing labor were allowed to increase substantially during the war. Between January 1, 1941 and April, 1945, average weekly earnings per worker increased by 77 per cent. This was, in considerable part, a result of increased working hours and a shift from low- to high-paid industries, but straight-time hourly earnings on the same jobs increased about 40 per cent against a cost-of-living rise of about 30 per cent.

The net result was to alter drastically the 40-year relationship of the 17½-82½ per cent division of Realized Income from Manufacturing. The share of wages and salaries increased to over 90 per cent, and the investment share shrunk to less than 10 per cent.

Its Postwar Distribution

This wartime shift in the proportion of distributive shares has an important bearing upon current wage controveries. With union demands for wage increases ranging up to 30 per cent, and the economists of the Office of War Mobilization and Reconversion asserting that an average increase of 24 per cent is feasible without raising prices, it is pertinent to inquire how such increases would affect the prewar ratios that governed realized income distribution in manufacturing.

Forecasting is always hazardous, but if we assume (1) that in 1946 we shall reach the $160 billion level of national output which the Government proponents of general wage increases expect, and (2) that there will be little increase in productivity because of the continuing process of reconversion, and (3) that the Government will succeed in carrying its announced purpose to maintain present price ceilings, it appears that a 24 per cent general wage increase would reduce the share going to capital from 17½ per cent to 11 per cent even allowing for its increased return resulting from the repeal of the excess profits tax. The prewar ratios would be about maintained if wages remained at present levels.

Conclusion

Since the maintenance of these prewar ratios was accompanied by an unparalleled rise in the "real wage" of American workers, there is a powerful prima facie case for not tinkering with them. It should be noted, however, that some economists think that the size of the investment share of manufacturing income tends to provide more capital than can be absorbed by a mature economy, and thus contributes to those breaks in the expansion of the economy which, as stated at the outset, have been its principal blight.

Regardless of what may ultimately prove to be the validity of this view, no one can responsibly contend that at this early but crucial stage in the reconversion process is the time to test it. Now, no one knows whether, or what dimension of, additional wage increases can be supported without forcing up prices or reducing profits to a point that will discourage vitally needed private capital investment.

We want high and increasing wages in American manufacturing. We need them to provide an active incentive to workers to support expanding productivity, as well as to continue the trend of rising living standards in America. Equally, we need a continuing profit incentive of sufficient attractiveness to call forth the new investment upon which expanding productivity depends.

We can never attain our dual objective if we push one of these aims so far and so fast that it defeats the other.

President, McGraw-Hill Publishing Co., Inc.

THE FAILURE OF "FACT-FINDING"

THE PRESIDENT has asked Congress to grant him authority to appoint fact-finding boards to deal with nationally important labor disputes. Most citizens would like to see some reasonable and objective solution of the industrial strife that now is disrupting reconversion. Unfortunately, the record of the "fact-finding" procedure indicates that any claim of impartiality for this process is a gross misrepresentation.

The Administration bill would authorize the President to appoint such boards in cases certified to him by the Secretary of Labor. Each board would report to the President "its findings of fact and such recommendations concerning the dispute as the board deems appropriate." Its facilities and staff would be provided by the Secretary of Labor. The bill provides for an interval of not more than 30 days known as a waiting or "cooling off" period during which it would be "unlawful" (though no penalties are specified) for anyone to promote or encourage work stoppages.

Because the Administration did not wait for Congressional action upon its proposal, but appointed a number of fact-finding bodies to deal with current emergency cases, we have been afforded at least a partial preview of how the procedure may be expected to work out if laws establishing it are passed.

If the reports handed down by the fact-finding panels in the General Motors and oil disputes may be regarded as representative, it can be stated conclusively that Government-appointed "fact-finding" boards will concern themselves to only a minor degree with the establishing of facts. A far greater share of their effort will be concerned with the speculative business of forecasting future output and production efficiency and appraising the "ability to pay" of the companies involved. But the predominant emphasis will be placed upon framing recommendations for settling the disputes in line with announced Government wage-price policy.

In short, the procedure essentially will be one of registering with the public a government opinion as to how far wages may be raised in the cases at issue without raising price ceilings. Both the General Motors and the Oil Panels stated, in quite explicit terms, that this was their conception of the job assigned them.

"Fact-Finding" in Auto and Oil Disputes

As the General Motors Panel phrased it: "This board subscribes to, and has been guided by, the national wage-price policy" — which it summarizes as calling for wage increases to maintain take-home pay at wartime levels, to the degree possible without inflationary price rises.

The Oil Panel was even more forthright in the statement of what it was supposed to do. "In the judgment of the panel," it declared, "the earnings of the workers must be as high as is consistent with both the maintenance of the stability of the price structure and the provision for reasonable returns to the owners of industry." In other words, prices and the return to investors are to remain fixed, with labor entitled to an ever-increasing return up to the limit of what the traffic will bear.

Having thus outlined their respective conceptions of the job, each panel proceeded to carry out its mission.

The Automobile Panel recommended that General Motors increase its basic hourly wage rates by 19½ cents, which amounts to about a 17½ per cent increase on the company's average hourly wage of $1.12. The Oil Panel recommended an 18 per cent increase in basic hourly wage rates, or an additional 21 cents to the average wage rate of $1.20.

The General Motors recommendation was based almost exclusively upon the Panel's calculation that a 19½ cent raise would keep weekly take-home pay equal to that earned in 1944 when the work-week averaged 45.6 hours. The calculation turned on an estimate of what the effective work-week was likely to be in 1946.

The Oil Panel's recommendation appears to have been based on a more complex but no more conclusive accounting. After calculating that the maintenance of July 1945 take-home pay after 40-hour shifts were restored would require a 22 per cent increase in straight-time hourly wages, it recommended that an 18 per cent increase be made. It accounted for 9½ per cent of this by noting that this was needed to cover cost-of-living rises, and explained that the rest was justified by a combination of factors including loss of premium overtime pay, higher productivity, and settlements already negotiated. Since the Panel gave no indication of the weight given to these several factors, it may not be unfair to assume that the last-named was given preponderant importance, since 18 per cent was the increase already granted in collective bargaining by Sinclair and certain other oil companies.

Higher Pay Without Higher Prices

Both panels stated that the pay increases recommended could be met without raising price ceilings, but neither documents its case on this score with very conclusive "facts".

The Oil Panel confined its observations on this account to the statements that only one company in its group had pleaded "inability to pay" and that the industry was in a generally profitable position during 1943 and 1944.

The Automotive Panel stated that, under a number of assumptions about the 1946 operations of General Motors which it believed to be valid, the Company would have higher earnings than it had in 1941, its previous record year. It specifically stated that its findings in the case were not applicable outside the

automobile industry, but it recognized that the General Motors settlement would more or less determine the settlements of other automotive companies. It stated that it had not been able to arrive at a clear conviction as to the ability of other auto makers to pay similar wage advances, but it dismissed the issue by observing that they could expect to operate at full capacity in 1946, and that this should provide savings to offset the increased wage expenditures.

From the management point of view, one of the most serious limitations in the panels' procedure was their failure to deal with any of the Company claims put forward. In ordinary collective bargaining the demands of both sides are advanced and concessions in one direction are traded for concessions in the other. Here, although the companies involved had insisted upon their need for guarantees against contract violations and wild-cat strikes, and for other union concessions, nothing but the wage issue was considered by the "fact-finding" bodies. The General Motors Panel specifically recommended that the wage increase of 19½ cents be granted, but that otherwise "the status quo prevailing before the strike be restored by the reinstatement of the 1945 contract between the parties." Handled thus, fact-finding becomes indeed a wholly one-sided exercise.

Both panels accepted, quite uncritically, the general position taken by Government spokesmen that wage increases are inflationary only if they are directly translated into price advances. It should be obvious that all wage increases add to the inflationary pressure, if made at a time like the present when consumer purchasing power far outstrips the volume of goods and services available to satisfy it.

"Fact-Finding" Dodged in Steel and Rails

It is ironic, too, that even while the Automotive and Oil Panel groups were holding the "government policy" line, the President and his Reconversion and Stabilization Directors were busily at work trying to dent it. In the steel dispute, although price rises in this industry have a particularly sharp inter-industry impact, hearings by the appointed fact-finding board were deferred while negotiations were carried forward by the President and his advisors under which the industry was offered a price increase of approximately $4.00 a ton on condition that U. S. Steel and the United Steelworkers agree upon a mutually acceptable wage boost. It is hard to avoid the cynical conclusion that wage increases constitute the major administration policy, and that the principle of not translating them into increased prices is sacred only in those cases where there can be some reasonably plausible showing that wages may be raised without price advances.

Much the same general conclusion — that the "facts" are controlling only if they support a substantial wage increase — is sustained by the history of the administration of the Railway Labor Act of 1926, often cited as a glowing example of how "fact-finding" by so-called Emergency Boards of Presidential appointees has served to prevent strikes on the railroads. It is true that reports of almost all of the 31 Emergency Boards appointed to look into threatened railway strikes in the 20 years since the act was passed have provided the basis for a settlement of the disputes in question. The fact — a real fact — remains, that in 1941 and again two years later the wage adjustments found appropriate by Emergency Boards in major railway labor disputes were revised upwards at the White House after the unions involved rejected them as unsatisfactory and threatened to strike. The second upward revision was made after government seizure of the railroads to prevent a national transportation tie-up. When the "facts" did not indicate a large enough wage increase to satisfy the union and the Administration, the "facts" went out the window.

It would be irresponsible to deny the importance of finding some tenable solution of current disputes that threaten to completely disrupt the reconversion process. But upon the evidence of experience, "fact-finding" boards cannot be expected to operate according to the common conception of their function — as agencies designed to sift out for the public an objective and significant weighing of the facts behind conflicting claims.

Without Principles Facts Mean Little

Facts, if they are assembled upon a sufficiently partisan basis, can be made to document almost any case one wishes to establish. The major difficulty in marshalling facts to resolve wage disputes is that there are no agreed-upon principles to determine the levels at which wages should be set. In the absence of such principles, it is inevitable that "fact-finding" boards, appointed by the Administration, manned largely by those who helped develop and administer Administration wage policies, and depending for technical assistance upon Administration Departments, will serve merely to implement Administration wage policy.

If Government means to reassert its wartime authority to fix wages — an objective specifically disavowed by the President and seemingly wanted by no one — it should accept the responsibility directly, rather than operate to that end through "fact-finding" boards which are independent in theory, but which cannot be so in fact.

The failure of the brand of "fact-finding" now urged upon Congress by the President is evident. Therefore, we must look for a solution along other lines.

What is needed is for labor and management to agree upon the principles that should govern the determination of wages under free collective bargaining. When such agreement is reached, then and only then, can fact-finding become an objective and useful instrument for settling wage disputes.

President, McGraw-Hill Publishing Co., Inc.

LOAN TO BRITAIN

. . . *Investment in World Economic Unity*

CONGRESS should give swift and confident approval to the proposed loan to Great Britain.

Few other issues of foreign policy in the present troubled world lend themselves to such clear appraisal of where our National interest lies.

In simplest terms, the question is whether we should extend to Great Britain a credit of $3¾ billions (plus $650 millions in payment for lend-lease balances) in return for her promise to repay principal with interest over a fifty year period starting at the end of 1951, and her pledge to give the fullest possible support to the kind of world trading system which it is the declared policy of both the United States and the United Nations Organization to promote.

We Can Afford to Make It

The sum we hazard is not inconsiderable, but financial risks have meaning only when related to resources. The line of credit provided by the loan will amount, at most, to a claim on 2/5 of 1 per cent of our gross output for the five to six year period over which it may be used. The interest rate charged, while moderate, is higher than our Treasury is paying upon current borrowings. The risk entailed is well within our resources as a creditor. In the considered judgment of the American and British technical experts who thrashed through the intricate accounting for three painful months, the amount and terms offered will suffice to allow Britain, under rigid austerity, to relax her system of foreign trade restrictions, and to expand exports sufficiently to pay her debt commitments.

Against the considered risks of extending the loan, there must be weighed the certain costs of refusing it. Without the loan, Britain has no recourse but to maintain and extend the system of bloc trading which she adopted under stress of world depression and world war. If that is the route Britain follows, she will carry with her a large part of the sterling area countries – all British Commonwealth and Empire countries (except Newfoundland and Canada) plus Egypt, Iraq, and Iceland—and many of the nations with which the United Kingdom has payment agreements (Argentina, Bolivia, Brazil, Chile, Paraguay, Peru, Uruguay, Belgium, Czechoslovakia, Denmark, Finland, France, Netherlands, Norway, Portugal, Spain, Sweden, and Turkey).

Altogether, the United Kingdom's orbit accounts for more than half of the world's imports and exports combined. It likewise is crucial to the trade of the United States. In the years immediately preceding the war, the sterling area and payment-agreement countries provided just under one-half of both the import and export trade of this country.

Russia, of course, will continue to conduct her foreign commerce exclusively upon a state-trading basis. Before the war, the Soviet Union transacted only a little more than 1 per cent of foreign trade business, but its future sphere of influence will be large—conceivably embracing as much as 30 per cent of total international trade.

We Cannot Afford to Refuse It

If the weight of British influence in foreign trade is thrown toward the Russian pattern rather than toward ours, it is apparent that bloc trading, with all of is supporting devices—bilateral deals, exchange controls, import and export quotas, subsidies, currency manipulations and the like —will be the prevailing pattern for foreign transactions.

In self-protection, the United States would have no alternative but to conform to the dominant pattern. We should be forced to form our own bloc, and to enter into active economic warfare in bidding for trade concessions against the offers of our rivals. How well we would do this is problematical. To the game we would bring the largest economic potential in the world. But our handicaps would be equally impressive.

First, under a system in which political and economic motivations are inextricably fused, a democratic nation, and particularly one with a tradition of freedom in its domestic enterprise, would operate at a great disadvantage. We should inevitably be driven toward more and more government control of our entire economy.

Second, with a pattern of foreign trade in which our exports habitually are greater than our imports, our bargaining position in international trade is much weaker than our over-all economic strength would suggest. Under state-controlled trading we should still find it difficult to compete successfully without resort to loans, and under these conditions our loans would be supporting a system alien to our choice and interest.

Third, under a regimented system which made economic decisions subservient to political considerations, it is virtually certain that the volume of world trade would shrink. That was the clear experience of the nineteen-thirties. Thus, the

standard of living in the United States would suffer in common with all others, and we would be forced into a particularly drastic curtailment of certain war-expanded segments of our economy, at the very time when a large portion of the world is most in need of the products they can produce.

Weighing the Alternative Costs

In the years immediately ahead it is certain that from two-thirds to three-quarters of all international trade will be transacted either in pounds or dollars. If both circuits are linked in a determined effort to restore competitive world markets, to which buyers and sellers alike have access without discrimination, that will be the dominant system of foreign trade. If the sterling group with its satellites organizes a closed grid, our exclusive effort cannot preserve the trade pattern that we believe offers most to us and to the world.

No one can accurately measure the costs to the United States of refusing the loan and accepting the consequences. But unquestionably they would dwarf to insignificance the sum risked in the proposed credit. We would lose through the shrinkage of our trade, through the wrench of violent readjustments in our production patterns, and eventually through the curtailment of our over-all output below what it would be under an open rather than a closed system. We would lose heavily in economic liberty under a procedure that can be followed with success only by a close regimentation of production as well as trade.

Most of all, we would lose in prestige, through demonstrating that we are still unprepared to exercise a world leadership to which our giant stature as the possessor of almost half of the world's economic capacity entitles us. Once again we would be exhibiting to the world political feet of clay supporting an economic frame of heroic proportions.

It Is Far from a "Soft" Bargain

There has been some disposition in this country to regard the loan to Britain as a somewhat "soft" and generally unprecedented transaction that smacks of charity. This is the sheerest nonsense.

In the first place, the kind of economic system we want has never functioned and cannot operate now without a lender. For many decades prior to World War I Great Britain filled the creditor role. In 1913 her foreign investments totaled $19 billions, and she not only made such transactions pay, but they proved her salvation through two grim wars. Her credits helped in the industrial development of a large segment of the world, including the United States. Of all the nations in the world, only the United States can assume now the mantle which Britain no longer can support.

In the second place, the terms of our proposed loan to the United Kingdom are far from easy. Britain put a substantially greater proportion of her relatively meager resources into the war than we did, and dissipated a large share of her foreign holdings in the process while accumulating an outside debt of crushing magnitude. On a per capita basis her internal debt is greater than ours. Many Britons feel that our proposed loan is too small, and its terms too rigorous. If the amount proves to be inadequate, we shall have to consider supplemental aid at a later date. But the majority believe that the present offer gives a fighting chance to restore the system of world trade that we and they both want, and upon which the World Bank, the Monetary Fund, and the International Trade Organization under United Nations aegis are based. It is certain that without our loan all of this will go by the board.

In the third place, our proposed loan is far from being without precedent. Canada, which is linked by far closer economic ties to us than to the Empire, already has provided for a loan to Britain of $1,200,000,000. This amounts to almost a third of what we propose to lend, although Canada's population is less than 10 per cent, and her income is little more than 5 per cent of ours.

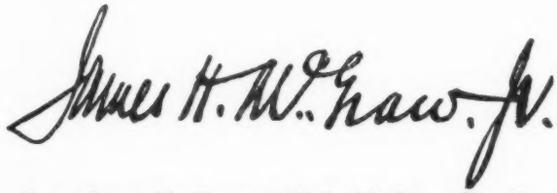
Shall the United States Lead or Follow?

The way to exercise leadership is to lead. Nothing could be more futile than to go half way toward establishing the economic order for which we stand, and then withhold the crucial measure that will make it work. Failure to approve the loan to Britain will be a clear default of leadership. Failure to approve it promptly will dissipate its effectiveness.

It has been officially stated that the British loan is a unique case that will establish no precedents for further credits to other nations. It is exceptional in its importance to our aim. But if the United States expects to make its economic program the dominant one for world trade, it must continue to exercise the creditor function without which that program cannot persist.

The most that we should ask is that future loan transactions be scrutinized as was this one to see that they offer comparable security and comparable return in support of the program for which we stand.

For the loan to Britain, it can be said that never before has one nation had an opportunity to gain so much at so little risk as has the United States in this uniquely decisive case.



President, McGraw-Hill Publishing Co., Inc.

HOUSING CAN COST TOO MUCH

EVERYONE in the United States wants our people, and particularly our war veterans, well housed quickly. Almost everyone, we believe, likes the vigor and imagination with which Wilson W. Wyatt, the housing expediter, is going about the job of mobilizing our housing resources.

No one, however, wants the veterans, or anyone else, to get a lot of severe economic headaches along with the housing. As it stands, the emergency housing program runs unnecessary risks of having such results.

Here are the reasons:

1. The principal opportunity the program offers to the veteran is that of buying a high-cost house where a chance to rent would, more often than not, meet his needs much better.

2. At the worst possible time, the program adds substantially to the dangers of a runaway inflation of the sort that inevitably ends in a crash.

3. Little is done to try to reduce the arbitrarily high costs of building, such as those resulting from restrictions imposed by labor unions and antiquated building codes.

4. By giving overriding priorities to unattainable goals of home construction, the program endangers a volume of industrial construction necessary to sustain full employment.

Needs of Veterans

First on the needs of the veterans. What many, if not most, veterans need is a chance to rent a place at a reasonable rental while they are getting shaken down in their postwar careers which in many cases are inevitably unsettled at this time. Essentially, what the "Veterans Emergency Housing Program" gives them is a chance to buy, for about $6,000, a house built along conventional lines and padded with much unnecessary labor and material cost.

But what are the alternatives? There are at least two. One is to put far more emphasis on more effective use of existing housing than the Wyatt program has thus far. The other is to see that the proportion of new rental units is much stepped up.

Incredible as it may seem, there are at present more than 2,000,000 vacant dwellings in the United States. Many of them should be demolished. But many permit of relatively satisfactory temporary use. Many more single dwellings can readily be converted into comfortable multiple dwellings. The emergency program assumes that only 350,000 dwelling units can be provided this year by these expedients, but it does not seem unreasonable to assume that this figure might be doubled by a vigorous drive. The result would be a better balanced emergency housing program, because it would provide more rental housing immediately and save critical building materials.

Of the new housing units contemplated by the Wyatt program, it is estimated that only about 20 per cent will be for rent. Before the war more than half of the homes in the United States were rented. That means that unless the Wyatt program is to create little less than a revolution in the terms on which homes are occupied, it must be revised to include a much higher proportion of rental units.

To secure the result in the face of present high building costs special inducements will be required. They might be provided by allowing accelerated tax amortization of, say, half the construction cost over the next five years, together with rent ceilings high enough to make this form of investment attractive. This would, of course, call for higher rents, but the actual price to the veteran, in woe as well as money, might well be much less in the long run than if he bought an over-priced house now.

Too Easy To Pay Too Much

One of the mysteries of the Wyatt program is its general emphasis on measures to increase the supply of money with which to buy houses when the demand for houses is already at an all-time high. Some veterans may need special financial help, but the plan to give 90-95 per cent mortgages generally on new homes is not only unnecessary but positively dangerous. By providing up to $3.5 billions of government-guaranteed credit for homes this year, and almost twice as much in 1947, the program will release an equivalent amount of individual savings to create further demand for goods and services. All that such generous mortgage terms will accomplish with certainty is a dangerous lengthening of the odds that we will not avoid a boom and bust cycle of inflation.

If building codes were brought up to date and arbitrary union working restrictions were eliminated, the way would be paved for reductions in the price of standard houses which, it has been estimated, might run as much as 20 per cent. This would both give the buyer of a new house a far better run for his money, and also reduce the inflationary pressure created by the super-generous credit arrangements involved.

Getting anything done along this line is difficult, particularly because the restrictions are imposed by tens of thousands of separate localities and organizations. Some headway is being made. The local emergency housing committees being set up under the Wyatt program provide a means of doing much more. Far more steam must be put behind this aspect of the program, however, if its greatest potentiality for permanently constructive accomplishment is to be realized.

Crippling Essential Industrial Production

The goals set for emergency housing construction —1,200,000 new homes started this year and 1,500,000 started in 1947—are higher than any qualified authority thinks can be met without crippling other essential construction. The reasons commonly assigned for such optimistic goals is that they are inspiring to those in the industry and soothing to those who want something tremendous done about housing.

Under normal circumstances, relatively little damage might be done by such excessive goals which are a common feature of most Washington programs trying to elbow their way to the center of the national stage. However, the emergency housing program carries with it top priorities for the materials to be used. Consequently, other essential construction will have to get along on whatever share of critical building materials will be left after all demands of home builders have been satisfied.

The Civilian Production Administration estimates that output of important materials will fall far short of needs. It forecasts a 15 per cent deficit in lumber, 18 per cent in bricks, and 52 per cent in cast iron radiators. Hence, unless building materials output can be stepped up far more rapidly than now seems possible, a prohibitive squeeze will be put on industrial building to provide the materials needed for the Wyatt program. This would complicate unbearably the problems of sustaining full employment and getting the flow of production so important in avoiding the boom and bust route.

Perspective on the Housing Shortage

What is needed is an aggressive drive to get full production of building materials as rapidly as possible. Such a drive should concentrate on measures aimed at helping the industry remove the obstacles to all-out production rather than on such measures as the subsidy plan which seems quite likely to succeed only in enmeshing the industry in more government controls. After making due allowance for the materials outlook and the needs for essential non-housing construction, housing goals should then be set as high as feasible. As matters stand, by setting construction goals before feasible material goals are determined, the cart is put before the horse.

There can be no doubt about the acuteness of the housing shortage and the necessity of a program commensurate with the magnitude of the problem. It also remains true, however, that the housing shortage for the nation as a whole is not quite as desperate as those who want the country to drop everything and go to building houses would have us believe.

During the war 3½ to 4 million new dwelling units were built or created by remodelling in other than farm areas. The number of families living in such areas increased by less than 3½ million. Even though some of this housing was located in remote places as an adjunct of war production works, the wartime increase permitted a margin for more housing per family at this time. Indeed, it has been estimated that the rate of doubling up is only about one-third as great as in 1940. The margin did not begin to suffice, however, to meet the needs of those millions of people particularly in the lower income groups who, thanks to rapid increases in income, can afford to have and insist upon having better housing than they have ever had before.

A rising standard of income which makes possible a new standard of housing for many people is a fine thing. Above all, it is important to see the veterans get the best possible break in housing.

But Housing Can Cost Too Much

The Wyatt program has many good features. The emphasis on prefabrication, though perhaps overoptimistic, is hopefully modern. The emphasis on local collaboration in solving housing problems which are inevitably in large part local should lead to permanently valuable results. The vigorous mobilizing of 300,000 temporary dwellings to meet at high speed some of the most desperate shortage is all to the good.

The main trouble with the program is that it does not pay enough attention to the economic havoc which may be created in the process of trying to meet its excessive goals. As a nation, we should be and are willing to pay a high price to get adequate housing. But the price will be too high if we:

1. Give the veteran a bad bargain by selling him an over-priced house.
2. Cripple industrial production needed to create good jobs for veterans, and
3. Touch off a disastrous inflationary sequence in the process.

These pitfalls can be avoided. All of us, including the veterans, have a common interest in seeing that they are avoided.

President, McGraw-Hill Publishing Co., Inc.

Congress has acted—and along these lines—since this editorial was written. If the President signs the legislation, we have taken one step forward. If he vetoes it, the voters must resolve a conflict between two branches of their government.

THE LABOR CRISIS
—*it's up to Congress*

IT HAS remained for John L. Lewis to demonstrate conclusively that, under the sponsorship of the federal government, the power of organized labor has been built up to a point where it can be used to paralyze the economic life of the nation. Therefore, in the elemental interest of self-preservation, the first order of the day is to cut down the power of organized labor to a point where irresponsible leaders no longer have the power to use it to cut down the country.

This will prove an exceedingly complicated job. The federal government, over a dozen years, has developed and buttressed the power of organized labor by many separate steps. They are interlaced in a pattern which cannot easily be unravelled.

Cutting down the power of organized labor to proper proportions will be an operation almost as delicate as brain surgery. To be successful it must impair no basic American political or economic right. It must leave intact the right of workers to organize and bargain collectively through representatives of their own choosing. It must leave intact the right to strike. But it must disassociate from the exercise of these rights opportunities for devastating abuse of the public welfare such as those demonstrated by Mr. Lewis. A meat axe is not the instrument for this operation.

Because of the complexity and delicacy of the operation to be performed it would be helpful if it could be carried out in a tranquil atmosphere. The urgency of the problem is such, however, that no time can be lost in getting at it.

Guiding Principles

However, the dangers that haste or heat will lead to serious blunders can be largely eliminated if the process of bringing the power of organized labor back within safe and reasonable bounds is governed by principles to which all fair minded people can fully subscribe.

The most important of these principles is that it is an abuse of public authority to extend special privileges to organized labor.

When in 1935 Congress passed the Wagner Labor Relations Act, one of the great buttresses of the power of organized labor, it was upon the explicit theory that organized labor was weak and needed coddling by the federal government if it were to survive, let alone grow big and strong. In the policy section of that act it was stated that "the inequality of bargaining power between employees who do not possess full freedom of association or actual liberty of contract, and employers who are organized in the corporate or other forms of ownership association substantially burdens and affects the flow of commerce . . . "

Regardless of whether or not that was a correct reflection of the situation in 1935, it bears no relation to the situation today. Under the continuous sponsorship of the federal government, the power and bulk of organized labor has waxed until today it is preposterous to regard it as the weak sister in its bargaining with employers. If, after being continuously demonstrated since V-J Day, the proposition that the pendulum of organized power has swung too far over on the side of organized labor needed any final and clinching demonstration, John L. Lewis provided it.

Changes in the Law

Translation of the principle that organized labor is no longer a weakling, requiring a diet of special privileges, into specific legislative enactments is a detailed technical operation beyond the scope of this statement. It is possible, however, to indicate some of the general lines it should follow. Here they are:

1. The duty to bargain collectively, now imposed upon employers by the Wagner Act, should also be imposed upon the leaders of organized labor who are now under no legal compulsion to bargain.

For well over a month Mr. Lewis made a complete mockery of the process of collective bargaining by refusing even to state his demands until the coal operators had approved "in principle" a plan for a miners' "health and welfare" fund which he fancied. In the meantime the country was plunged into an ever deepening crisis.

2. Unions, as well as employers, should be made liable to suit for damages for breaking their collective bargaining agreements.

A degree of responsibility commensurate with their age and power requires that unions be liable, to the extent of union funds but not the funds of individual members, for carrying out their agreements. To have it otherwise is to hold that a collective bargaining agreement is, by defi-

nition, a phoney agreement so far as the union is concerned. Outlaw strikes are the fruit of this lop-sided arrangement.

3. Employers should be given more discretion, in reinstating employees who have gone on strike than is now permitted by the Wagner Act.

The Wagner Act largely eliminates the risks involved in striking because of the requirements it imposes upon employers to take workers back when they have decided to return to work. These requirements make it virtually impossible for the employer to replace workers even if they are engaged in the most unjustifiable of strikes. At the least workers who have smashed up property and stirred up violence in the course of a strike should have no rights under the Wagner Act. How much further the Wagner Act straitjacket should be loosened at this point should be carefully explored, and excesses encouraged by the Act should be removed.

4. The wedge which the National Labor Relations Board has driven into the orderly conduct of American industry by holding that foremen are covered by the Wagner Act should be eliminated.

The issue involved here is continuously mislabelled and confused as that of the right of foremen to organize. There is no question of the right of foremen to organize any kind of a legal organization they desire. That is their right as American citizens. The issue is whether or not the special privileges accorded by the Wagner Act, which in some circumstances has been so construed as even to prevent employers from talking with their workers, should be extended to foremen who, if American industry is to have a chance to do its duty effectively, must represent management with full loyalty and responsibility.

A member of John L. Lewis' United Mine Workers takes an oath which provides, in part, "that I will not reveal to any employer or boss the name of anyone a member of our union" and will "defend on all occasions and to the extent of my ability the members of our organization." Mr. Lewis insists that the coal operators contract to deal with foremen to be organized in a union where they will take that oath, and where their activities will be separated from the influence of employers by the barriers imposed by the Wagner Act. Such an arrangement undercuts orderly management of American industry.

5. The exemption of labor unions from the federal anti-trust laws, provided when organized labor was presumed to be weak, should be modified to take account of its vastly increased strength, and the use of this strength to destroy business enterprise and create monopoly.

As matters stand unions can run employers completely out of business by secondary boycotts and run fellow workers out of jobs in the process. An Ohio manufacturer, working with a government-certified C. I. O. union, is put out of business because A. F. of L. workers refuse to handle his products. Still the government, this time in the person of the United States Supreme Court, says that actions of this sort are above the law because Congress exempted unions from the federal anti-trust laws.

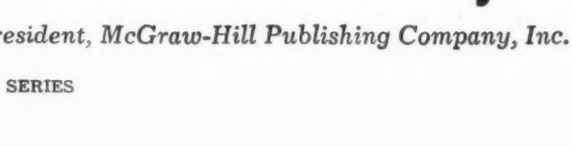
To eliminate one of the most devastating forms of restraint of trade, this exemption should be cut down forthwith by subjecting unions imposing secondary boycotts to the same penalties under the federal anti-trust laws as those to which employers doing the same thing are subjected. And the question of further narrowing the obsolete exemption of unions from the federal anti-trust laws should be fully explored.

6. The levying of special sales taxes for the exclusive benefit of unions should be prohibited by law.

As a matter of good government the right to levy consumption taxes should be reserved to the public authorities and used strictly for public purposes. As a matter of good economics, payments to workers or their organizations should be included in the payroll where they can be properly counted as part of the cost of production.

Equality Before the Law

When everything that can conceivably be accomplished by legislation has been accomplished there is no reason to believe that an ideal or even a surely workable system of industrial relations will have been devised. Many of the mainsprings of such a system lie deep in the hearts of men and far beyond the reach of legislation. There is no chance, however, of having such a system, or even a defensible system of democratic government until special privileges which tip the scales of power far on the side of organized labor are withdrawn and there is some measure of equality for employers and organized labor before the law. Though it is hard to believe it at the moment the country may come to be grateful to John L. Lewis for driving that lesson home so ruthlessly.



President, McGraw-Hill Publishing Company, Inc.

OPA IS DYING—
. . . what next?

IT IS NOW clear that direct price control of the OPA type is on the way out, if not by legislative limitation then by administrative collapse.

It is equally clear that we are by no means past the danger of a swirling upsurge of prices.

Then does it follow that the passing of OPA need be tantamount to a decision to let 'em rip?

It does not.

While the OPA machinery is grinding to a stop, we can bring into play more fundamental measures to keep prices within safe limits—and to allow private management a wider area of freedom. What this article proposes is a framework of control within which private business judgment can operate. Therefore, this preamble speaks directly to our friends in the business community.

Now is a time for unrelenting self-restraint by business management. As price control disintegrates, business must scrupulously hold to prices which, after covering costs, yield *normal* profit margins. Business has everything to lose and nothing to gain if its price policies emulate the excessive wage demands made by some unions.

True leaders of business sense the danger. They do not want to price themselves out of their markets. They do not want the tag of price hogs. They do not want a buyers' strike. All management must practice the self-restraint which characterizes the wisest leaders among us.

What Wasn't Done

Virtually all responsible economic analysts agree that if direct price control is eliminated and nothing else is done, prices will move upward. The only serious disagreements are: How far? And for how long?

Some careful and competent forecasters believe that, if all price control is lifted, the official cost of living index will shoot up at least 25 per cent within a year. Some of them think that wage rates will chase right after prices, forcing new price increases until the whole operation ends in a dizzy crash.

Others agree that prices will go up all right, but they think that increased production, made possible by disentanglement from OPA red tape, will bring them down again fairly soon.

Recent developments seem to support those forecasters who think that wage increases would chase right after price increases and thus keep "the inflationary spiral" spinning toward a ghastly fall. Unions already agitate for a new round of wage increases to offset price increases which have occurred in the few months since the last round of wage increases.

Therefore, the prudent course would have been to clean up the OPA price control system, to keep it in place for a limited period as a stop-gap, and, meanwhile, to arrange to replace it with more fundamental controls, PROVIDED the federal government itself stopped promoting excessive wage increases. *The greatest single contribution to the wrecking of the OPA has been the holes driven in price ceilings by government-promoted wage increases.*

But now the stop-gap is being eliminated, and the fundamental controls are not in place. Their erection becomes urgent.

The Basic Task Now

The danger that prices and wages will get to chasing each other around a ruinous spiral arises, of course, from the accumulation during the war of an enormous sum of money that could not be spent because about 40 per cent of the nation's production was being devoted to war. Men were paid wages and profits for making artillery shells. The shells were exploded. The money remains. It has piled up until the people's backlog of cash spending power, in one form or another, exceeds $225 billions—three times the total in 1939.

More than that, banks hold $115 billions of government securities—a sixfold increase since 1939. These securities can serve as the basis for an expansion of bank credit of many times their volume. A dollar of bank credit will, of course, buy as much as a dollar of cash.

The first and basic task of preventing runaway prices is: *Get this huge accumulation of purchasing power, actual and potential, under some kind of effective control.*

A second task is to see that no unnecessary additions are made to the flood of purchasing power overhanging the market. A third task is to get the productive machinery of the country running at top speed so that it can take up the accumulation in an orderly way, not in a boom-bust sequence. We shall talk here only about the first two of these tasks.

Are there ways of getting at the root cause of a disastrous wage-price spiral which are being neglected? There are many of them. Attention has been distracted from them by building up the battle over OPA as the Armageddon of price stabilization. It is important. But it is not Armageddon. If everything that Mr. Bowles and his associates want done by way of price control legislation were done, the problem of price stabilization would still remain unsolved in the continued absence of a program to deal effectively with root causes.

Basic Remedies

Here is a rough outline of the key elements of a basic program.

1. Cut public expenditures to the bone and let tax revenues accumulate as business volume increases—perhaps broadening the tax base at the same time.

Now, if ever, is the time to run a surplus and to use it to retire debt. Immediate upward pressure on prices would thus be removed and the burden of carrying debt when the going gets tougher later on would be relieved. A $10 billion surplus of federal, state and local revenues during the next year might not be too much.

An increase in social security taxes, as the House Ways and Means Committee proposes, offers one of a number of good ways to increase revenues. Deferring public works not immediately needed affords one of numerous ways by which substantial cuts in expenditures can be made.

2. Tighten the terms on which installment credit is available for the purchase of houses, automobiles, and other consumers' goods.

Allowed to run a free course, expansion of credit to buy houses and durable consumers' goods might easily add $15 billion to consumer purchasing power next year. No such injection of credit is needed now. The more a man buys "on time" the more cash he keeps to spend on something else. For most products the cash market alone is more than big enough to keep producers busy and customers healthy.

3. Restore to the Federal Reserve system its lost control over the supply of credit by limiting the opportunities for credit expansion now afforded by huge bank holdings of government securities.

The specific measures needed are highly technical, but are agreed upon by banking experts as both feasible and fair. The important thing for the public at large to do is to recognize that we are, in effect, sitting on a powder keg with lighted match in hand until the measures are taken.

4. Revive a vigorous campaign to sell government savings bonds and other government securities to the public.

Sale of government savings bonds cuts down current consumer spending. It also allows the Treasury, if government spending is held down, to retire government bonds which the banks hold. Thus, it simplifies the problem of keeping bank credit within safe bounds.

5. Prevent a speculative inventory boom of the sort which preceded the post-World War I business collapse in 1920-21.

This involves a continuation of the loose controls of inventories now exercised by the government. In more important degree it involves well informed cooperation by bankers and business men to keep inventories from being expanded unnecessarily.

6. Maintain controls on exports in order to keep within reasonable limits the impact on our market of huge foreign demand.

Emergency foreign relief requirements must be met. But foreign demand which is enormous apart from relief requirements must be kept under control until the danger of having it send prices of export products soaring is past.

Breathing Space for Business

This program would deal with causes, not symptoms. Hence, if promptly and efficiently installed, it would do a far better job of keeping the general level of prices and wages within tolerable limits than the OPA type of price control ever could have done—even if OPA had not been so often and so badly mismanaged. The program would also do this without tying up American business in a myriad of irritating and discouraging individual regulations. It would establish broad bounds within which business enterprise would be free to be itself, not a branch of bureaucratic enterprise.

The program proposed here also has the major virtue of flexibility. If prices start to reverse their present upward course within another year, the major parts of the program can be adjusted or removed quickly.

It would be gratifying to suggest junking at once all arrangements designed to place limits on price movements, even broad limits of the sort here suggested. But to do nothing while OPA falls apart, would be to run the grave risk of a runaway of prices and wages which, in the inevitable collapse, would do irretrievable damage to the business community and to the whole nation.

The risk is not worth taking.

President, McGraw-Hill Publishing Company, Inc.

THIS IS THE 49TH OF A SERIES

LABOR DAY • 1946

—Time for wise union leadership

LABOR DAY, 1946, finds one hopeful element in the relations between American management and labor which was not there on Labor Day, 1945. It comes in recent expressions by a number of national leaders of organized labor that increased "real" wages depend upon *increased productivity,* i.e. increased output per man-hour. Increased money wages which are promptly offset by higher prices do nobody any good.

If these expressions, *which still remain to be substantiated by practical performance,* come to be accepted by the rank and file of labor in each community, Labor Day, 1946, can usher in a period of great and perhaps unprecedented improvement in the economic wellbeing of wage earners—as well as the wellbeing of the country at large. If, on the contrary, they remain merely window dressing and there is a continuation of the post V-J Day process of increasing wages and then prices, the outcome can only be the bursting of an inflationary bubble, with attendant suffering for workers and the community generally.

Competition requires management to bear down heavily on increased labor productivity as a prelude to wage increases. Management, however, has rarely made a more forthright statement on the importance of increasing labor productivity than that contained in a recent issue of LABOR'S MONTHLY SURVEY, an official publication of the American Federation of Labor.

William Green, the Federation president, led off with a "message to American workers." He remarked, "Our major need is increased volume of production." Observing that "wage increases this spring have been paid for by raising prices," the survey itself goes on to say that "Today America's ability to raise wages without increasing prices and living costs depends on increasing productivity in civilian industries . . . Here is the challenge to free labor and free enterprise today: *Cooperate to increase productivity and raise living standards without strikes.*" (Italics supplied.)

The importance of increasing production was also recently stressed by Walter Reuther, President of the United Automobile Workers, C.I.O., who remarked that his union "is just as eager as management to get the (automobile) industry into maximum production." In taking this general line he was in accord with the position of Philip Murray, head of the C.I.O., who in a book, "Organized Labor and Production" written with Morris L. Cooke, remarks that, "The modern labor leader also realizes that to receive a good day's pay a man must do a good day's work and that *increased productivity has been the vital factor in the country's industrial supremacy and its relatively high wage scale.*" (Italics supplied.)

In citing increased productivity as the key to increased "real" wages these labor leaders—and management—have the historical record entirely on

SPOT CHECK ON LABOR OUTPUT

In the absence of reliable general statistics on what has happened to productivity of labor since V-J Day (because of strikes and reconversion complications) the McGraw-Hill Publishing Company asked the executives of a cross section of American industry to report their own impressions. The questions asked and summaries of the replies, which varied markedly from industry to industry and plant to plant, follow.

Question No. 1. How well have workers performed since V-J Day as compared to their pre-war effort?

Answer. Worker effort has been below pre-war. There are exceptions, particularly among older and more experienced workers; and there are quite a few signs of improvement.

Question No. 2. How much headway have you been able to make since V-J Day in improving labor productivity by better equipment and organization?

Answer. Some headway is generally being made, but it has been greatly retarded by inability to get new equipment and, in some cases, by lack of labor cooperation in improvements in organization.

Question No. 3. How much improvement in equipment and organization is to be anticipated in your business over the next year?

Answer. Marked improvement in productivity (in a few cases as much as 20 per cent) can generally be made if there is sustained production and full cooperation between labor and management.

their side. In the 40 years prior to the outbreak of World War II output per man-hour for the country as a whole was approximately doubled. Over the same period the "real" hourly earnings of industrial workers were also approximately doubled. There were, of course, great variations in the increase of output per man-hour from one line of activity to another. Also, there were periods when increases in "real" wage rates lagged behind increases in productivity. But for the 40 year period as a whole and the economy as a whole there is no mistaking the fact that the route to increased "real" wage rates was increased productivity.

Three economic factors played major roles in this doubling of production per man-hour which has made America the industrial marvel of the modern world. One was the skill and diligence of American workers. A second was the skill and diligence of American management in organizing production. A third was the improvement of machinery and the increased application of power to it.

Wartime Record

During World War II this sustained increase in the productivity of labor in *civilian* manufacturing industries, which had averaged about 3 per cent a year, was brought to an abrupt halt. Much of the most efficient segment of the nation's labor force went to war or war industry. Also, civilian industry was starved for new equipment while we equipped our arsenals. The result was that the productivity of labor in those civilian manufacturing industries for which the government keeps records actually declined throughout most of the war. By 1945 it was no higher than in 1941, whereas, if it had maintained the long run average, it would have been about 12 per cent higher. In the meantime, however, average hourly wages in these civilian industries had increased about 40 per cent.

In *war* industry, which started from low levels of production at strange tasks, there were substantial increases in output per man-hour. Many of these increases involved new processes, improved techniques, and better machines which can be adapted over a period of time to the improvement of productivity of labor in civilian industry.

Since V-J Day, however, labor, led on by a misguided government, has had its sights on higher money wages instead of improving productivity which would have laid the foundation for increased "real" wages. Consequently, debilitating industrial strife ended in a round of wage increases which, in the absence of increased productivity, is being washed out by higher prices.

To Keep Production Rolling

However, as indicated by the summary of a McGraw-Hill sampling of the current experience of industry in increasing output per man-hour, which appears in the center of the page, there is hope that the situation ahead can be improved. After agonizing delays because of work stoppages, material shortages, and reconversion complications, industrial production is beginning to roll again. Allowed to roll it will not be long before it will be making those advances in productivity which are the only true basis for increased "real" wages.

If the process of keeping American industry rolling to new highs of productivity is to be resumed, management must see that the past practice of translating increased output per man-hour into increased "real" wages is not only sustained but wherever possible accelerated. For its part organized labor must abandon its manifold feather bedding rules and other production-restricting practices which afflict considerable segments of American industry. Further it must give incentive systems of pay, honestly conceived and honestly administered, a fair break. *Management and labor and government and the community at large must collaborate in removing that specter of working one's self out of a job which has been one of the greatest causes of restriction of output.*

The current emphasis by leaders of organized labor on the economic truth that increased output per man-hour is the only road to increased "real" wages is important. The next step is to see that recognition of this truth seeps into the rank and file of labor and industry and becomes the basis of a program of action at the local level. If it does, and quickly, Labor Day, 1946, may mark a tremendous turning point toward sustained prosperity not only for labor but the community at large. If it does not, union leadership will fail in its responsibility and must answer to the American people for the consequences of such a failure.

President McGraw-Hill Publishing Company, Inc.

A FREE ECONOMY IS WORTH FIGHTING FOR

BUSINESS must take the initiative if the price decontrol machinery, set up by Congress, is to be effective. The present price control law is far more than a set of instructions to the administrators of OPA; it is a challenge to business to be aggressive in speeding decontrol decisions and in persuading the Price Decontrol Board to adopt a strong stand for return to a free economy.

Thus far business has not met this challenge. *Two months after the passage of the new price law not a single application for decontrol of a major product had been filed by an industry advisory committee.* This is due in part to the red tape controlling such applications. Nonetheless, a continuation of such inactivity on the part of business can well result in perpetuating price control far beyond the time either the present law or sensible economic policy require.

It was the clear intent of Congress to hasten our return to a free economy. In the legislation continuing the general control of prices, Congress formally declared its purpose to have it "terminated as rapidly as possible."

To accomplish this, the House originally approved a formula which would have made decontrol mandatory when production had attained a prescribed level. The automatic decontrol provision was dropped before the bill was finally passed, partly because of the uncertain effects of strikes on production. But Congress did not mean to return the timing and extent of decontrol to the administrative discretion of OPA.

On the contrary, to assure having price control "terminated as rapidly as possible," Congress created a Price Decontrol Board and gave it power to overrule OPA when the board finds price control should be removed. Moreover, it gave to industry the right and the responsibility to seek decontrol. Also, in a further effort to speed up the decontrol process, it placed narrow limits on the time allowed for board decisions.

Congress had compelling economic reasons for doing its legislative best to speed up decontrol.

1. It is by all odds the best way to eliminate the bottlenecks in production and the black markets which have plagued the country since V-J Day.

   Rigid price ceilings promote shortages of badly needed commodities by discouraging their production. Such shortages both upset the flow of production and promote black markets. At present a considerable part of American industry is stymied by shortage of critical parts and materials. Price control is much to blame.

2. There must be flexibility of prices if a round of new wage adjustments, which may be forced on industry early in 1947, is to be negotiated without grave risks of seriously curtailing production.

   When, under the leadership of the national administration, the first post V-J Day round of wage adjustments was made, price ceilings were held rigid while wages were boosted. The result was a series of price-wage squeezes which upset production. They would have been disastrous if we had not been in a sellers' market, created by a tremendous accumulation of wartime shortages. In 1947, however, many industries will be in a buyers' market. It must be possible, therefore, to have wage increases reflected promptly in price adjustments if we are to avoid a repetition of the costly post V-J Day round of strikes, which often had price control as the key issue.

3. Rapid decontrol is necessary to maintain a high level of employment and production.

   Almost five years of price control inevitably twisted the factors of production and distribution far out of the equilibrium which would prevail in a free economy to which it is the clear purpose of the nation to return. Unless the return to a free economy is facilitated by a speedy and orderly decontrol, the jolt of an abrupt return to competition can be expected to upset employment and production seriously.

It's Up To Business

To encourage speed and boldness in decontrol, Congress provided for the reimposition of control over any prices which, after being released, might

get out of hand. The dangers of this sort are chronically exaggerated. During the 25-day period in July when there was no price control the Civilian Production Administration found that "manufacturers of finished industrial and consumer products have generally exhibited commendable restraint in increasing prices no more than increased costs."

All of this endeavor to speed up decontrol and expand its scope is likely to be futile, however, unless business furnishes the driving power for the machinery Congress provided. OPA certainly will not do it. Neither can the Decontrol Board be expected to go out and drum up cases.

The necessity for vigorous action by business in pressing for decontrol is increased by the fact that the general legislative standards to guide decisions by the Decontrol Board are vague. They must be clarified and sharpened by decisions in specific cases.

The main principle to guide the decontrol of non-agricultural products is that price ceilings shall be removed when supply is in approximate balance with demand. But what precisely does that mean? The meaning will become clear only through Decontrol Board decisions.

The same is true of the principle which makes automatic decontrol of a non-agricultural commodity contingent on whether or not it "is important to business costs or living costs." Business must press cases which will give specific meaning to those vague terms if decontrol is to get on apace.

Cards Are Stacked

At present the government has the cards pretty well stacked against rapid decontrol.

First, the key members of the staff of the Price Decontrol Board are holdovers from the Bowles regime which emphasized the importance of carrying on price control rather than speed in getting rid of it.

Second, in exercising his authority to prescribe regulations to govern petitions for decontrol, the OPA administrator has required excessively complicated statistical and economic data. Manufacturers who are sure they can convince any fair-minded board of the desirability of decontrolling certain of their products assert that they are blocked by statistical entanglements.

Third, OPA has discouraged business from moving immediately under one section of the law to speed decontrol. This section provides that products "not important in relation to business or living costs" may be freed from price ceilings immediately and must be freed by December 31, 1946, unles OPA specifically finds they are important to these costs. Instead of making it possible for business to move under this section now, OPA has issued rules which have the effect of blocking such a course until the end of the year.

In the light of obstacles such as these, it is not surprising that the record of decontrol to date is not impressive.

Decontrol Record

Since June 30 there has been a drop from about 70% to about 60% in the total value of products under price control. But most of the drop has been accounted for by food products, which Congress took the lead in decontrolling, and by industrial machinery which was being decontrolled when Congress acted. By far the larger part of manufactured consumer goods remains under control.

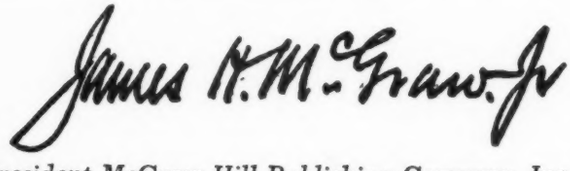
This, however, is no time for business to be discouraged. Rather, business should accept the obstacles put in its way as a challenge and work harder than ever for speedy decontrol.

The case for decontrol should not be stated in narrow technical terms. It should be based on grounds of broad public policy, and should demonstrate how a speedy return to a free economy can hasten the full release of the nation's productive power.

For example, there should be very clear demonstrations of how, in far too many cases, rigid price ceilings—(1) discourage production of key parts and materials by making such production relatively unprofitable, (2) create shortages of key parts and materials which tie up broad ranges of production or result in piling up lopsided inventories of partially completed goods, and (3) thus cut away the foundations of a stable economy and the prospects of steadily sustained employment.

There should be equally full demonstrations of the well known sequence from shortages to unrealistic price ceilings to black markets. Meat prices are rolled back, but the meat is rolled under the counter.

A free economy is worth fighting for. Liberty is preserved only by the constant struggle of those who believe in it. Neither the interests of the nation in a strong and well-balanced economy nor the interests of business itself will be served by drifting at this time. Now is the time for business to lead a strong offensive for speedy elimination of price control.



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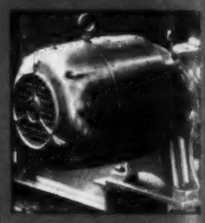
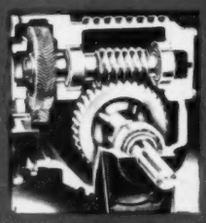
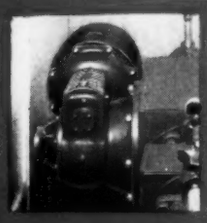


the RIGHT *horsepower*



the RIGHT *shaft speed*



the RIGHT *mounting*

All of these . . . the explosion-proof motor, the gear-reduction unit and the flange mounting . . . all are standard Master units that easily combine into one compact, integral power drive for this double action proportioning pump. This integral construction permits many parts to be stripped away from both the power unit and the completed machine and pays off handsomely in savings in material . . . savings in space.

Probably you will not need exactly this same combination of features, but Master Gearmotors are available in any size from 100 down to 1/10 horsepower and in all cycles, phases and frequencies . . . in open, splash-proof, fan-cooled and explosion-proof types . . . with Speedrangers and Unibrakes . . . for every type mounting . . . and over a gear reduction range up to 432 to 1.

Use Master Gearmotors to increase the salability of your motor-driven products . . . improve the economy, safety and productivity of your plant equipment. They're the horsesense way to use horsepower.

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